

# New Scientist

WEEKLY September 19 - 25, 2015

**BORN IN A STORM**  
Africa's wild climate  
drove human evolution

**BLACK HOLE ESCAPE**  
Falling into one isn't  
as final as it sounds

**FEELING AWUMBUK?**  
...and other emotions  
English can't name

## RENEW YOURSELF

Why aging isn't irreversible

### DUMBED-DOWN DOGS

Domestication  
made them stupid



No3039  
US\$5.95  
CAN\$5.95

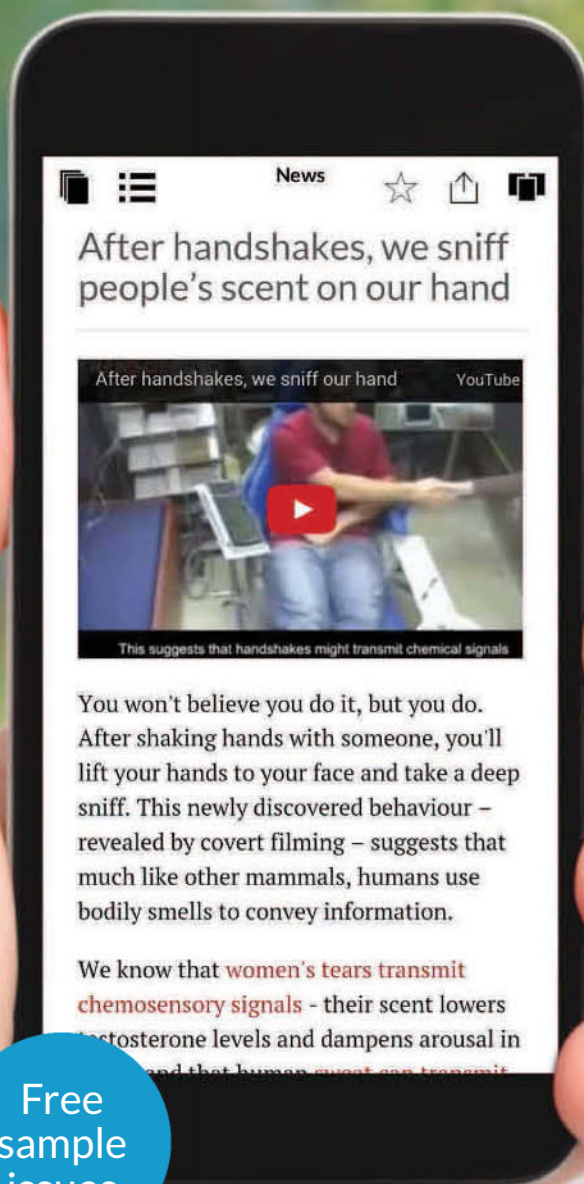
Science and technology news  
[www.newscientist.com](http://www.newscientist.com)  
Faculty Career Feature



## SPACE ODDITIES

 Exoplanets are weirder than we ever imagined





Free  
sample  
issues



**New  
Scientist**


# See science everywhere

Enjoy free sample  
issues within the app

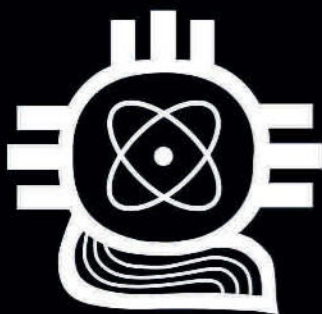
Download the  
*New Scientist* app today

Available on the  
 **App Store**

ANDROID APP ON  
 **Google play**

 Download from  
**Windows Store**





# 2015 SACNAS NATIONAL CONFERENCE

The **Diversity in STEM** Conference.

**Join us for the nation's  
largest multidisciplinary  
and multicultural  
diversity in STEM  
conference.**

Scientific innovation thrives when scientists from different backgrounds and disciplines come together. Join us in the nation's capital for an interdisciplinary meeting of the minds where science, culture, and community intersect to provide innovative solutions to our greatest scientific challenges.

**3,800+**  
participants

**1,100**  
student research presentations

**350**  
exhibitors

**100+**  
breakout sessions



**Science • Culture • Community**

**OCTOBER 29 – 31, 2015**

**Gaylord National Resort &  
Convention Center**

Washington, DC Metropolitan Area

Register at **www.2015sacnas.org**



**sacnas.org**  
**info@sacnas.org**  
**1-877-SACNAS-1**

*Advancing Chicanos/Hispanics  
& Native Americans in Science*



## News

# 8

## How climate shaped humans

Wild climate drove human evolution



STEVEN MCCURRY/MAGNUM

## On the cover

# 30

## Renew yourself

Why aging isn't irreversible

- 8 Born in a storm**  
Climate drove evolution
- 11 Black hole escape**  
Falling in isn't final
- 39 Feeling awumbuk?**  
Emotions English can't name
- 14 Dumbed-down dogs**  
Stupid by domestication
- 34 Space oddities**  
Exoplanets get weirder



Cover image  
Sam Falconer

## Features

# 34

## Space oddities

Exoplanets are weirder than we ever imagined



MATTHEW BORRETT

## Coming next week...

### Retrain your moral brain

Our sense of right and wrong needs an upgrade

### The everything factory

Making materials that never existed

## Leader

- 5** Only full disclosure of drug trial results can keep pharmaceutical firms honest

## News

- 6 UPFRONT**  
ISIS chemical weapons. Lab-made sperm. Global warming's role in Japan's floods
- 8 THIS WEEK**  
Cuba leads fight against lung cancer. Freeloaders bring crowdsourcing success. Black hole escape. Weather chaos as hottest year approaches. Domestication made dogs lazy thinkers. Pluto dazzles in HD
- 12 INSIGHT**  
Antidepressant suicide and self-harm data released at last
- 16 IN BRIEF**  
Can red wine really prevent Alzheimer's? Speed-dating birds. Moonquakes uncovered

## Technology

- 20** Unhackable world. Adverts that read your face. Smart homes controlled by thought. Social network pays you to share

## Aperture

- 24** Living fossil re-emerges

## Opinion

- 26 Compassion's wake-up call** We don't have to tune out suffering, says Daryl Cameron
- 26 Palm oil** Consumer pressure is reforming an agricultural villain, says Curtis Abraham
- 27 One minute with... Alfredo Alvarez** My life transporting antennas for Chile's ALMA
- 28 Evolution of sex** Justin Havird on why animals and plants do it

## Features

- 30 Renew yourself** (see above left)
- 34 Space oddities** (see left)
- 39 Feeling awumbuk?** ...and other emotions English can't name

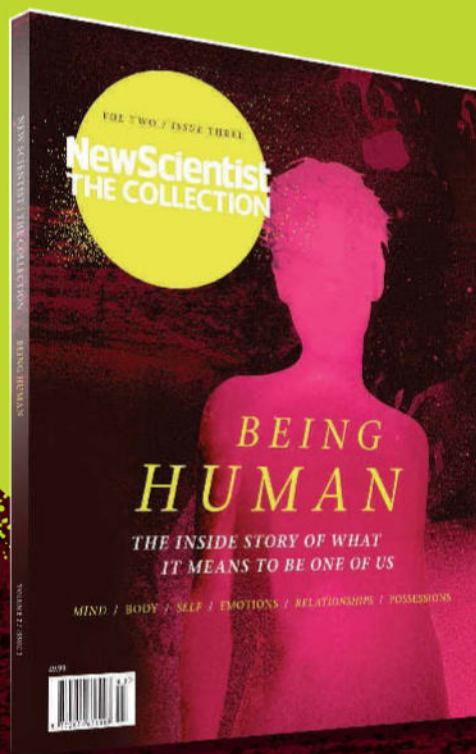
## CultureLab

- 42 Inheriting what?** Even if it's possible to build a better world, we may not deserve it
- 43 Lessons to learn** Reading the past reveals how not to treat 21st-century refugees

## Regulars

- 54 LETTERS** Flagging our motion in time
- 56 FEEDBACK** Science of dolls
- 57 THE LAST WORD** Railing against it





# THE HANDBOOK OF YOU

Mind, body, self, emotions, relationships, possessions. Read the inside story of what it means to be one of us.

Buy *Being Human* in all good magazine retailers or digitally. Find out more at [newscientist.com/TheCollection](http://newscientist.com/TheCollection)

**NewScientist**



## NewScientist

## LOCATIONS

## USA

225 Wyman Street,  
Waltham, MA 02451  
Please direct telephone enquiries to  
our UK office +44 (0) 20 7611 1200

## UK

110 High Holborn,  
London, WC1V 6EU  
Tel +44 (0) 20 7611 1200  
Fax +44 (0) 20 7611 1250

## Australia

Tower 2, 475 Victoria Avenue,  
Chatswood, NSW 2067  
Tel +61 2 9422 8559  
Fax +61 2 9422 8552

## SUBSCRIPTION SERVICE

For our latest subscription offers, visit  
[newscientist.com/subscribe](http://newscientist.com/subscribe)

Customer and subscription services are  
also available by:

**Telephone** 1-888-822-3242

**Email** [subscribe@newscientist.com](mailto:subscribe@newscientist.com)

**Web** [newscientist.com/subscribe](http://newscientist.com/subscribe)

**Mail** New Scientist, PO Box 3806,  
Chesterfield, MO 63006-9953 USA

One year subscription (\$1 issues) \$154

## CONTACTS

## Contact us

[newscientist.com/contact](http://newscientist.com/contact)

## Who's who

[newscientist.com/people](mailto:features@newscientist.com)

## General &amp; media enquiries

[enquiries@newscientist.com](mailto:enquiries@newscientist.com)

## Editorial

Tel 781 734 8770  
[news@newscientist.com](mailto:news@newscientist.com)  
[features@newscientist.com](mailto:features@newscientist.com)  
[opinion@newscientist.com](mailto:opinion@newscientist.com)

## Picture desk

Tel +44 (0) 20 7611 1268

## Display advertising

Tel 781 734 8770  
[displaysales@newscientist.com](mailto:displaysales@newscientist.com)

## Recruitment advertising

Tel 781 734 8770  
[nssales@newscientist.com](mailto:nssales@newscientist.com)

## Newsstand

Tel 212 237 7987  
Distributed by Time/Warner Retail  
Sales and Marketing, 260 Cherry Hill  
Road, Parsippany, NJ 07054

## Syndication

Tribune Content Agency  
Tel 800 637 4082

© 2015 Reed Business  
Information Ltd, England.

New Scientist ISSN 0262 4079 is  
published weekly except for the last  
week in December by Reed Business  
Information Ltd, England.

New Scientist at Reed Business  
Information, c/o Schnell Publishing Co.  
Inc., 225 Wyman Street, Waltham,  
MA 02451.

Periodicals postage paid at  
Boston, MA and other mailing offices.

Postmaster: Send address changes to  
New Scientist, PO Box 3806,  
Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a  
newspaper and printed in USA by Fry  
Communications Inc, Mechanicsburg,  
PA 17055



LUBITZ + DORNER/PLANET PICTURE

# Publish, or be damned

Only full disclosure of drug trial results can keep firms honest

TAKE a prescription drug, and you also take a leap of faith: faith that your doctor has made the right diagnosis, that you won't suffer an adverse reaction, and that the company that developed the drug didn't conceal anything about it from the authorities.

The last of these ought to be the least of a patient's worries. Sadly, the pharmaceutical industry has a shameful track record on this front. Time and again, companies have been caught pulling the wool over regulators' eyes in a bid to get their products on the market.

One of the most egregious cases was that of the painkiller rofecoxib, or Vioxx. Launched in 1999, it was used by about 80 million people before its maker, Merck, pulled it in the face of compelling evidence that it increased heart attack risk – a fact the company knew but kept secret for five years.

Sharp practice of this kind is still widespread. Drug trials are not always registered. The results of around half never see the light of day, and positive results are more likely to be published than negative ones. As a result, the evidence on which regulators and doctors make life-and-death decisions is fragmentary and biased in the interests of the drug companies.

That needs to change, and it is changing. From next year, all clinical trials in the European Union will have to be registered in a publicly accessible database, and all results published within a year of the trial ending.

This is welcome, but it is not enough. It will only apply to future trials, even though most medicines were approved based on trials done long ago. There are also fears that the new regime will

**“The evidence on which regulators and doctors make crucial decisions is fragmentary and biased”**

not prevent the industry hiding negative results. In fact, it could make matters worse by creating the impression that the problem has been solved.

The new system does not, in fact, demand full disclosure. Companies will merely be compelled to release documents known as clinical study reports. These are more detailed than journal articles but do not contain full information, down to the level of individual participants.

Releasing such fine-grained data is problematic as it can reveal the identity of anonymous volunteers, which is why companies will not be made to do

so. That may seem an acceptable compromise, but some critics say it fails to eliminate the temptation for companies to bury bad news.

The no-compromise position has now been vindicated by a fresh analysis of the data from a notorious clinical trial called Study 329. Carried out in the 1990s, it was the first to find a link between the antidepressant paroxetine (sold as Paxil or Seroxat) and suicidal behaviour. The drug's manufacturer, GlaxoSmithKline, did not disclose this information until compelled to do so by a court ruling. GSK did not, however, have to release full patient data.

Now those results have been analysed by independent researchers, who say the suicide link was stronger than previously revealed (see page 12). This, they say, shows that total transparency is the only way to stop drug companies from cheating us.

Further progress is possible. Researchers are developing ways to release full data without compromising anonymity. And GSK deserves belated credit for finally releasing all the data from this particular trial: other companies take note. But it is clear that if the case for full disclosure was already strong, it is now overwhelming. ■

## Corbyn patchy on science

HE WANTS Charles Darwin's birthday to be a public holiday. And he accepts that human activity is warming the planet – he has pressed the current UK government to double its 2030 targets for cutting emissions of carbon dioxide from 40 to 80 per cent. But where does Jeremy Corbyn, new leader of the UK's Labour Party, stand on mainstream political issues that rest on science, technology and medicine?

Corbyn has raised eyebrows by appearing to support homeopathy, despite a lack of scientific proof that it works. In one infamous tweet in 2011, Corbyn said he believed that homeopathy “works for some people” and complements conventional medicine because “they both come from organic matter”.

But in a positive move, Corbyn has created a shadow minister for mental health – a position with no opposite number in the government. In February, he spoke in parliament on why he thought mental health was such an important issue.

Corbyn also says that Trident, the UK's nuclear weapons programme, should be scrapped.

Last month, he affirmed his backing for scientific and technological research. “The UK has produced some wonderful scientists and engineers – real innovators in their fields, but too often we do not have the supportive infrastructure to develop their ideas here,” he said. “Only a strategic state that supports innovation can close this infrastructure deficit holding the UK back.”

## ISIS gas attacks

CHEMICAL warfare seems to be alive and kicking in Syria and Iraq.

The world breathed a sigh of relief when Syria's chemical weapons were destroyed last year. But reports have been coming in of the militant group ISIS attacking Kurdish towns in Syria and Iraq with mustard gas, and of ISIS and the Assad regime in Syria using chlorine gas.

Syria, and Iraq before the first Gulf War in 1991, had stockpiles of mustard gas, which causes severe blistering of the skin and lungs.

### “5000 chemical munitions were found after the 2003 Iraq invasion, including in areas now held by ISIS”

Officially, these have all been removed or destroyed.

But in August, victims of an ISIS attack in northern Syria showed symptoms of exposure to the gas. Last week, Gerhard Schindler, head of Germany's Federal Intelligence Service, said ISIS has begun mustard gas attacks against Kurds in north Iraq.

It is possible that ISIS is making the gas itself, Schindler says. One site where it could be synthesised might be the captured labs at the University of Mosul in Iraq.

But chemical weapons experts say it is easier to simply plunder old stockpiles. Mustard gas lasts a long time – it still persists in first world war shells, for example.

And stockpiles are probably still around. A report by *The New York Times* last year based on documents obtained under the Freedom of Information Act found that after the 2003 invasion, US forces found some 5000 pre-1991 chemical munitions in caches across Iraq, including areas now held by ISIS. Some ISIS leaders were members of the former Iraqi regime, says chemical weapons expert Jean-Pascal Zanders, so they might be familiar with how to recycle these.

The Syrian government, meanwhile, and opposition forces other than ISIS have denied using chemical weapons. On 27 August the UN launched a special investigation in an attempt to determine who is using poison gas in Syria.



Corbyn: made of organic matter

## 500-year-low snow

THE snow cover on the US Sierra Nevada mountain range has hit a 500-year low. This year's April level was at just 5 per cent of the historical average recorded for the month between 1951 and 2000.

It's bad news for drought-ridden California because melting snow from the Sierra Nevada range fills 30 per cent of the state's reservoirs (*Nature Climate Change*, doi.org/7p7). California suffered devastating wildfires this week that were fuelled by the

region's worst drought on record.

“Snow is a natural way to store water, and now with rainless summers, the only water available in California comes from melting of snow that fell the previous winter,” says palaeoclimatologist Valerie Trouet of the University of Arizona in Tucson.

The sparse snow cover resulted from unusually low winter precipitation combined with high winter temperatures, and the chance of this double whammy occurring again will increase with global warming, says Trouet.

## Bright spot mystery continues

What's that shining on Ceres? NASA released the best-ever pictures of the mysterious bright spots on the dwarf planet this week, but we still don't know what they are.

NASA's Dawn spacecraft has been orbiting Ceres, the largest object in the asteroid belt, since March. Bright spots in the 90-kilometre-wide Occator crater shone out from a distance and now Dawn has dived in for a close-up view. The latest photos reveal that what initially seemed like

two dots is actually a scattering of bright material set against the much darker landscape of Ceres.

Researchers have suggested it could be icy material within the dwarf planet exposed by an impact, or even created by ice volcanoes spewing water from an ocean beneath the surface. “Dawn has transformed what was so recently a few bright dots into a complex and beautiful, gleaming landscape,” says Marc Rayman, Dawn's chief engineer.



## Lab-made sperm

CAN we really make sperm in a dish? After claiming earlier this year that they had done just that, French researchers have now taken out a patent describing their technique.

**"We must make sure it's safe, ethical and acceptable for patients and regulatory agencies"**

Philippe Durand and Marie-Hélène Perrard at the biotechnology company Kallistem in Lyon, France, say that their method uses a bioreactor to coax seminiferous tubules taken from humans, rats or monkeys into producing mature sperm cells in 72 days or fewer.

Their aim is to freeze tissue from pre-pubescent boys who need cancer treatment, so that they would still be able to have biological children in later life.

The team hopes to begin clinical trials in 2017, if they are given permission to use lab-made sperm to fertilise a human egg. "We must make sure it's safe, ethical, secure and acceptable for the patients and regulatory agencies," says Perrard.

Stem-cell experts are declining to comment on the team's patent, saying that they will reserve judgement on the technique until the team has published their results in a peer-reviewed journal.

KYODO/AF/PA



Millions were evacuated

## Flooded Japan

UNPRECEDENTED rains in Japan last week killed at least seven people and washed away bags of soil contaminated by the 2011 Fukushima nuclear disaster. But why was the rain so severe?

It was mostly bad luck, says Brian McNoldy of the University of Miami, Florida. "Any tropical system, or even its remnants, can produce enormous rainfall."

As tropical storm Etau reached central Japan, it interacted with

immediate cause of this is the strong El Niño now under way, but global warming has also contributed.

McNoldy doesn't think we can say if El Niño and global warming played any part in the floods. But Masters thinks climate change may have made the rainfall more severe, because a warmer atmosphere holds more moisture.

**"Tropical storm Etau interacted with typhoon Kilo and lingered for longer than usual, fuelling floods"**

typhoon Kilo to the east, making it linger for longer than usual. "Etau and its heavy rain band stayed around longer than it would have otherwise," says Jeff Masters of the Weather Underground forecasting service. In places, over half a metre of rain fell in just one day, smashing previous rainfall records.

As Etau weakened and turned into an extratropical storm, a front formed that continued to dump rain on already saturated ground, worsening the flooding.

There has been a record amount of typhoon activity in the Pacific this year, driven by high sea-surface temperatures. The

## Stinging victory

BEEES won last week when a US court overturned federal approval for a bee-killing neonicotinoid pesticide called sulfoxaflor.

Judges found that the US Environmental Protection Agency (EPA) had relied on "flawed and limited" data and that its green light to sulfoxaflor maker Dow AgroSciences in Indianapolis, Indiana, was unjustified given the "precariousness of bee populations". Judge Randy Smith said he believed that the EPA registered sulfoxaflor in response to public pressure and supported its decision retrospectively with studies that it had previously found inadequate.

Environmentalists and beekeepers' associations, who initiated the lawsuit, think that the same criticisms of the quality of research highlighted by the court can be applied to other neonicotinoid pesticides.

## 60 SECONDS

### Jedi threat to seabirds

Helicopters will swoop in on Skellig Michael Island off Ireland's west coast this week, carrying equipment for the next *Star Wars* film. But conservation bodies are concerned that the government has allowed filming on what is a seabird sanctuary. They claim hundreds of kittiwake chicks were swept off a ledge into the sea by a helicopter down draught last year, during filming for the forthcoming *Star Wars: The Force Awakens*.

### Oceans of trouble

Marine vertebrates almost halved in numbers worldwide between 1970 and 2012, according to the campaign group WWF. It is calling on governments to create more marine protected areas and tackle climate change, which threatens to speed up the disruption of ocean ecosystems.

### Coffee lag

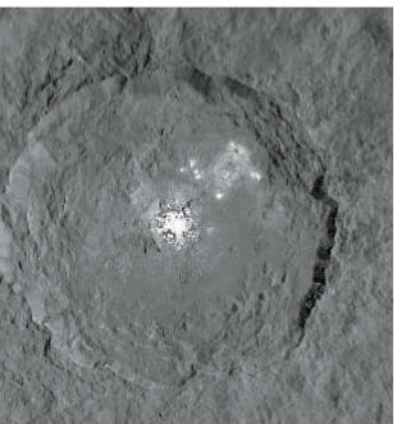
Coffee keeps you awake, and it also shifts your body clock. Taking a dose of caffeine equivalent to a double espresso three hours before bedtime makes people wake up 40 minutes later than normal. Caffeine seems to disrupt cycles of the sleep hormone melatonin (*Science Translational Medicine*, DOI: 10.1126/scitranslmed.aac5125).

### Camel-free Hajj

Camels are banned at this year's Hajj pilgrimage, due to start next week. Officials in Saudi Arabia will not allow them at holy sites at Mecca and Medina because they carry the coronavirus that causes MERS.

### Reactor rebooted

North Korea has restarted its nuclear reactor at the Yongbyon complex, according to state media. The director of North Korea's Atomic Energy Institute issued a warning to the US on Tuesday that the nation was prepared to use nuclear weapons if needed. The complex was shut down in 2007.



What's on Ceres?

NASA/JPL/CALTECH/UCLA/WPI/DLR/IDA

# Climate change shaped humans

Variable climate drove key moments in human evolution, reports **Michael Slezak**

HUMANS were born, almost literally, of fire and ice. Periods of wildly changing climate seem to have driven some of the major evolutionary steps that made us who we are.

The ways in which climate affected human evolution have been hotly debated for over a century. A persistent idea is that the challenging climate of southern Africa – a sparsely vegetated, dry savannah – drove humans to walk on two legs, grow large brains and develop technology. “I was hooked on the savannah-adaptation idea in my studies in the 1980s,” says Rick Potts from the Smithsonian Institution in Washington DC.

But by the 1990s, Potts had a new theory. “I realised that the critical part of the human evolutionary story is how our lineage was able to become so versatile... capable of invading habitats everywhere,” he says.

We’re not master savannah inhabitants, we’re master invaders. This led Potts to suggest that maybe it was environmental change itself – not a particular environment – that drove human evolution. “A rise in variability of climate places a premium on being nimble, versatile, to ensure survival,” he says.

A climate that shifts from wet to dry every 10 or 20,000 years would have selected for humans that had a capacity to adjust to change, whatever it may be. For example, big brains would have allowed us to solve problems caused by changes in rainfall, such as by making different stone tools to exploit changing food resources.

In 1996, Potts published the idea in a book, calling it “variability selection”. But it was just that: an idea. The trick was finding hard evidence.

Now, a series of papers by Potts and others finds evidence



suggesting he is right. “They show quite convincingly, I think, that the evolution of humans into large-brained, bipedal animals... has come about through a close and adaptive relationship with changing climate,” says Varsha Pilbrow from the University of Melbourne in Australia, who wasn’t involved in the work.

What was missing before was a clear link between periods of

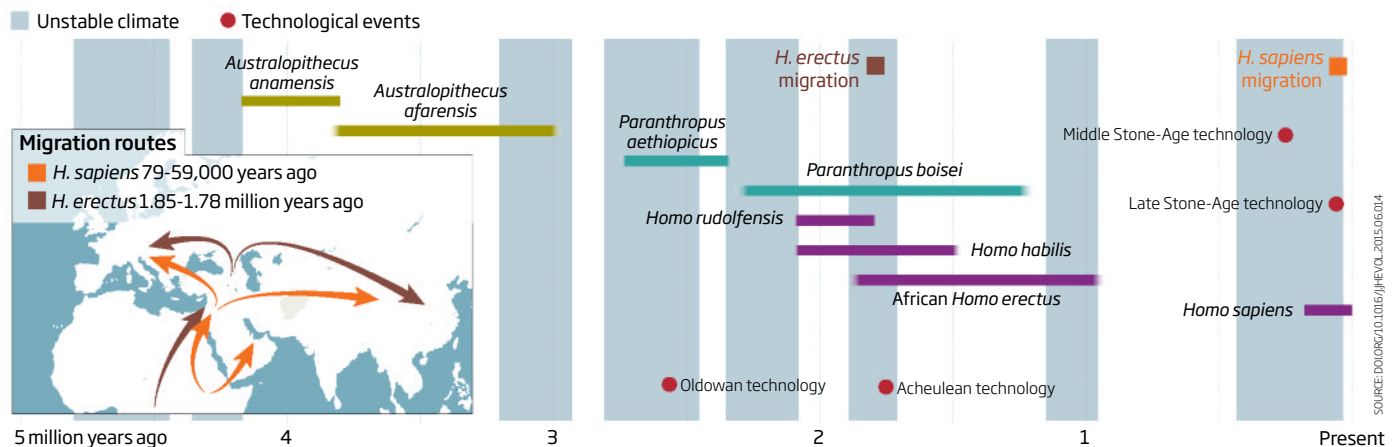
highly variable climate, and milestones in human evolution.

Over 15 years or so, Potts and others gathered evidence of past climates at sites where early humans lived. This allowed Potts to pinpoint periods of highly variable and stable climate at five such sites in Africa from between about 3.5 and 1 million years ago.

Potts then modelled the distribution of key evolutionary

## Human evolution driver?

Key events in our evolution, such as speciation and extinction, as well as migrations and technological innovations, have overlapped with periods of unstable climate more than expected by chance





## In this section

- Cuba leads fight against lung cancer, page 10
- Domestication made dogs lazy thinkers, page 14
- Unhackable world, page 20



Human, whatever the weather

events – things like speciation, migration and development of stone technology – over the past 5 million years, to see what you would expect if climate variability wasn't driving human evolution. They could then compare this with the actual distribution of events.

From chance alone, the team calculated that you would expect to see five speciation events overlap with periods of high variability. In reality, eight overlapped. Similarly, chance alone would predict about four of the seven technological shifts overlapping with climatic variability, but they found that six did (*Journal of Human Evolution*, doi.org/7pq).

## Migration correlation

Potts also looked at two key migration events out of Africa, into China and Indonesia. Both correlated with periods of variable climate. Pollen records from those regions show that they had different environments, suggesting humans were versatile invaders

rather than grassland specialists. "It's the first attempt at a rigorous test of climate-evolution cause and effect," says Potts. "It's gratifying to see that all the major hominin lineages, the major shifts in stone technology, the two major dispersals out of Africa, and the origin of *Homo sapiens*, all are correlated with prolonged high climate variability."

Matthew Grove from the University of Liverpool in the UK agrees with Potts that variability is responsible for human evolution, but with a caveat. He thinks that early humans would have gained their adaptable skills where they were, and only spread to new environments during calmer periods, once wild climate events had died down.

"It would have been easy for these populations to tolerate conditions in surrounding areas, because they would have already experienced those conditions in situ in the past," says Grove.

To see if they could tease out the exact timing, Grove and his colleagues decided to look at a single event in more detail. They studied one of the first human

migrations out of Africa, into the Middle East through Ethiopia. The team examined sediments from Lake Tana in Ethiopia and drew a detailed timeline of rainfall variability.

Using the rainfall record to work out when there was a lull in climate upheaval, their theory predicts a dispersal from the area between 97,000 and 112,000 years

## "A rise in variability of climate places a premium on being nimble and versatile to survive"

ago. The fossil record has wide error margins for this dispersal, but they centre around 102,000 years ago. Grove says this is perfectly consistent with his theory, but doesn't prove that it happened after the climate variability died down. That means it couldn't differentiate between Grove's and Potts's ideas, although it does lend support to the connection with variability.

"It suggests that human adaptability and plasticity has allowed us to ride the tide of climate change and disperse

globally in a successful way," says Pilbrow.

However, not everyone is convinced. The theory depends on assuming that these major changes in humans were a result of natural selection, says Darren Curnoe from the University of New South Wales in Sydney, Australia. He says it's just as likely that what Potts and others are pointing to as natural selection might actually be other types of evolution like random genetic drift or niche construction, which would mean climate didn't have any important role at all. "So just jumping to a selection-based scenario is putting the horse before the cart."

Potts disagrees. He says they tested for the idea that the associations were a result of chance or biases in fossil preservation. "We tried our best... and found that those factors can currently be discounted," he says.

John Stewart from Bournemouth University in the UK says the theory has merit and notes that if the model is true, we should see a similar effect with other organisms. And indeed there is evidence that some birds evolve to be more flexible in response to variable climates – and that this helps them colonise new areas.

"The next step is to catalogue all the available palaeoclimatic data and archaeological localities in East Africa to see how well the hypothesis really stands up to much more rigorous tests," Potts says.

So what does all this mean for future humans, as the climate seems set to change dramatically again? "It is cause for concern because humans are now a single species, highly specialised in their locomotor pattern and behavioural adaptations," says Pilbrow. We've lost the variation that came with having multiple species around, and there's nowhere left to migrate. Perhaps technology will once again come to the rescue. ■

## A ROCKY DESCENT FROM TREES TO SAVANNAH

Climate change may have driven our evolution by affecting rainfall and food (see main story). But plate tectonics would have changed the very shape of the land on which our ancestors lived. "This is a very much neglected area," says Matthew Grove from the University of Liverpool, UK. He says there's no reason to think that topography would have been any less important than climate.

Isabelle Winder from the University of York, UK, argues that complex, hilly terrains would have provided hunter-gatherers with shelter, tactical vantage points and basins that collected water. "These would be attractive areas for hominin habitation, providing ready access to subsistence needs, as well as protection from major predators like lions and hyenas," Winder says.

She believes that mixed landscapes would have been an easy first step out of the trees for our ape ancestors, before walking on two legs full time. "Unlike a move from arboreal climbing to terrestrial upright striding, such a transition wouldn't require rapid changes in anatomy," Winder says.

This implies our ancestors stuck to paths through complex landscapes as they migrated. In a preliminary analysis, Winder's team shows that corridors of such landscapes line up well with the distribution of early human fossils in Eurasia (*Journal of Human Evolution*, doi.org/7pr).

This points to potential routes within and out of Africa, says Grove, and it could also help us predict where to look for early human fossils.

# US-Cuba thaw may yield cancer drugs

Will Grant, Havana

CUBA has a unique relationship with tobacco. Cigars are the country's national product and tobacco generates an annual income of between \$400 and \$500 million. If you've ever walked down the Malecón of an evening, Havana's iconic waterfront promenade, you can't fail to have noticed the scores of young people pulling on cheap cigarettes in the sea breeze.

It still strikes me as odd when I see people smoking inside public buildings, and it isn't frowned upon to light up at your desk in most Cuban workplaces.

And therein lies the problem. Cancer is the second biggest cause of death in Cuba, after cardiovascular disease, and lung

cancer rates are among the highest in the region, according to the World Health Organization.

But Cuban researchers are helping lead the fight against the disease. They recently added a new weapon to the arsenal against lung cancer: Cimavax. This vaccine – designed to be given to people with cancer – encourages the immune system to attack a protein that fuels tumour growth, slowing the disease's spread.

"The basic idea is to mobilise the immune system so the components which typically defend you are able to fight the cancer cells growing inside the body," says Kaleb Leon, director of investigation and research at the Center of Molecular Immunology (CIM) in Havana, where the drug was developed.

There is one key reason why Cuba punches above its weight in the medical research arena: research and treatment are tightly connected in the Cuban healthcare system. Writing in the journal *PNAS* earlier this year, a group of US neuroscientists including Mark Cohen of the University of California, Los Angeles, noted the benefits of this "two-way communication between the lay public and research scientists in the cause of public health" ([doi.org/7qc](https://doi.org/7qc)). They cited large-scale population studies which "routinely achieve more than 95 per cent enrolment success".

Partly because of this connection, the team at CIM has made significant progress with clinical trials of Cimavax. Pooled results from phase I and II clinical trials showed that those vaccinated survived for 11 months on average,

**"An agreement has been signed to further test and develop Cuba's cancer vaccine in the US"**

while the survival rate in a control group was four to five months (*Human Vaccines*, [doi.org/dbgtw9](https://doi.org/dbgtw9)).

And the work has attracted international interest. On his recent trade visit to the island, Andrew Cuomo, Governor of New York, brought representatives from Roswell Park Cancer Institute in Buffalo. They have now signed an agreement with CIM to further test and develop Cimavax in the US.

Leon is clearly proud of his team's achievements as he guides me around the national immunology lab, housed in a modernist building on the outskirts of Havana.

"Roswell Park has been in touch with us for about three years now," he says. "The plan is to start a phase I clinical trial there at the end of this year."

But he admits it hasn't been easy. For over five decades, the US government has maintained an economic and diplomatic embargo on communist-run Cuba, which has made it almost impossible for researchers in the two nations to work together.

This year's *PNAS* article emphasised the benefits to the US of closer cooperation. Scientists in Havana, too, are aware that they would benefit from further detente.

"In many different senses this weird relationship we have with the US has caused problems for us," says Leon. The US forbids third nations from selling equipment containing US-made components to Cuba, for example.

But 2015 has seen quite a turnaround for these cold war enemies, including a face-to-face meeting between presidents Obama and Castro, diplomatic ties re-established and embassies reopened.

If the thaw is to last, however, it must take hold in arenas beyond diplomacy. Cancer patients on both sides of the Straits of Florida will hope biomedical research can benefit from this new-found spirit of cooperation. ■



PETER TURNLEY FOR HARPER'S/CORBIS

Keep it Cuban



## Crowdsourcing works best if some don't help

THERE are those who edit Wikipedia entries for accuracy - and those who use the online encyclopaedia daily without ever contributing. A new mathematical model says that's probably as it should be: crowdsourcing a problem works best when a certain subset of the population chooses not to participate.

"In most social undertakings, there is a group that actually joins forces and works," says Zoran Levnjajic at the University of Ljubljana, Slovenia. "And there is a group of free-riders that typically benefits from work being done, without contributing much."

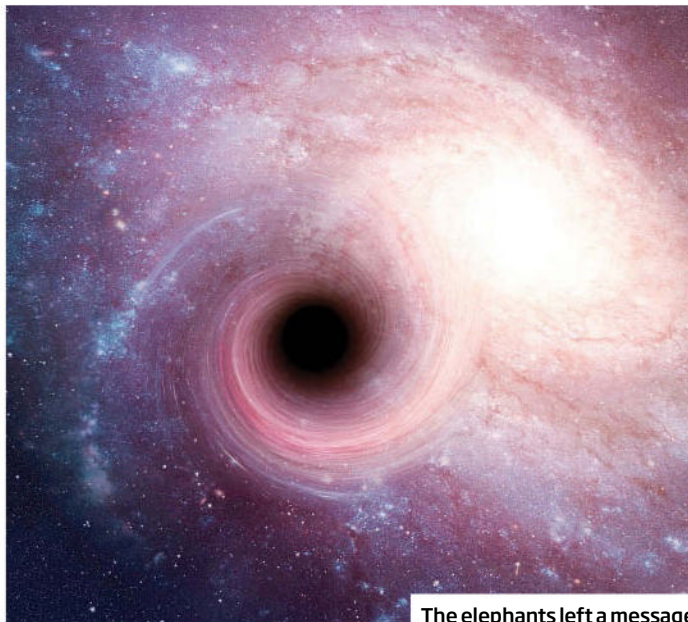
Levnajic and his colleagues simulated this scenario. Digital people in a virtual population each had a randomly assigned tendency to collaborate on a problem or "freeload" - working alone and not sharing their findings. The team ran simulations to see whether there was an optimum crowdsource size for problem-solving.

It turned out there was - and surprisingly, the most effective crowd was not the largest possible. In fact, the simulated society was at its problem-solving best when just half the population worked together.

Smaller crowds contained too few willing collaborators with contrasting but complementary perspectives to effectively solve a problem. But if the researchers ran simulations with larger crowds, the freeloaders it contained naturally "defected" to working alone - knowing that they could benefit from any solutions the crowd reached, while also potentially reaping huge benefits if they could solve the problem without sharing the result ([arxiv.org/abs/1506.09155](http://arxiv.org/abs/1506.09155)).

But does that happen in reality? "Crowdsourcing is interesting precisely because humans are not simple," says Krzysztof Gajos of the University of Harvard.

Consequently, Levnjajic's team will soon study the behaviour of real-world crowds. Sarah Scoles ■



The elephants left a message

## Black holes could bounce information back out

IT'S another salvo in the black hole wars. The edge of a black hole might be a brick wall against which information about in-falling stuff bounces back like a tennis ball, says Nobel laureate Gerard 't Hooft of Utrecht University in the Netherlands.

't Hooft was responding to Stephen Hawking's 25 August announcement of a new solution to the information paradox - a problem that has plagued scientists for 40 years.

The paradox is this: if any object, be it an iPhone or an elephant, ventures into a black hole, it stays there. From the outside, we will never be able to learn about any of its characteristics; information about it disappears behind the black curtain.

But in 1974, Hawking discovered that quantum weirdness at event horizons - the edges of black holes - causes them to leak radiation in the form of photons. This radiation, dubbed Hawking radiation, makes black holes slowly lose mass and evaporate.

Eventually, they pop completely out of existence, snuffing out all of the information that fell inside. But the laws of quantum mechanics say that information can neither be created nor destroyed, so it has to go somewhere. But where?

"The answer is that matter going into the hole has an effect

**"If any object, be it an iPhone or an elephant, ventures into a black hole, it stays there"**

on outgoing Hawking particles," says 't Hooft. "Hawking did not believe that at first, but gradually he is revising that opinion."

Hawking's new claim is that if, say, an elephant crosses over the boundary of a black hole, the information about its elephant-ness stays on the edge as a holographic imprint. When the Hawking radiation seeps out, it carries that imprint with it. But questions remained: how does the in-falling matter make a mark? And how does that mark

tattoo itself onto the outgoing radiation? "Hawking's paper generated a lot of discussion," says 't Hooft.

This made 't Hooft revisit an idea he had first proposed in 1987. "I realised I can do a better calculation," he says.

't Hooft thinks that gravity can answer both questions. As the elephant slips over the black hole's boundary, the animal's gravitational field changes. When outgoing Hawking radiation passes through that gravitational field, its path is altered, and can convey information about the doomed pachyderm.

Information about it, such as its mass, then bounces back into space - although the animal itself isn't so lucky.

"Even though we describe modes of in-falling matter that 'bounce back against the horizon', these bounces only refer to the information our particles are carrying, while the particles will continue their way falling inwards," 't Hooft writes in the paper ([arxiv.org/abs/1509.01695](http://arxiv.org/abs/1509.01695)).

't Hooft's and Hawking's ideas have a similar problem, however: information overload. Their solutions might actually make a second copy of the information, thus creating information instead of destroying it.

If the poor elephant goes into the black hole, all of its characteristics go with it. But that information also hangs out on the horizon in Hawking's case, or bounces back out in 't Hooft's.

"Quantum mechanics forbids such duplication," says theoretical physicist Steven Giddings of the University of California, Santa Barbara. It's also unclear how a gravity-only information transfer meshes with quantum mechanics. "The devil is in those details," says Giddings.

The battle over black holes is far from over. We will have to wait for further, conclusive salvos before victory can be declared over the mysteries beyond the event horizon. Sarah Scoles ■

ANDRZEJ WOJCIK/SPL/SHUTTERSTOCK

## INSIGHT Antidepressants

# New look at happy pill's downside

Clare Wilson

YOU may never have heard of it, but Study 329 changed medicine. It was the first trial to highlight serious problems with a common class of antidepressants, but only now have the full results been opened up to independent scrutiny. They show that one drug is even more likely to trigger suicidal behaviour than we thought.

Study 329 looked at paroxetine, one member of a family of antidepressants, the selective serotonin reuptake inhibitors (SSRIs) – once described as wonder drugs. When the study took place in the 1990s, these drugs were only approved for adults, and pharmaceutical firms were looking to extend their use to teenagers.

The first paper from the trial, published in 2001, involved 275 teens with depression. It concluded that paroxetine was generally well tolerated and had similar side-effect rates to placebo pills.

But by then several US lawsuits were under way, involving adults who had become suicidal or violent soon after starting these types of drugs. Paroxetine manufacturer GlaxoSmithKline later released trial

reports revealing that teens in the study had higher rates of self-harm and threatening to commit suicide than those on placebos.

Now GSK has given independent researchers access to the study's data set. Sifting through it, David Healy, a psychiatrist at the Hergest Unit in Bangor, UK, and his team found

15 instances of suicidal behaviour among 12 teenagers taking the drug, compared with four in the similarly sized placebo group (*BMJ*, DOI: 10.1136/bmj.h4320). The company's trial reports had suggested only 10 instances in those taking paroxetine.

In a statement, GSK said product labels have, for more than a decade, carried clear warnings about the increased risk of suicidal behaviour in adolescents. "As such, we don't believe this reanalysis affects patient safety."

But the findings show that only with all the figures can the risks and benefits of medicines be weighed up,

says Healy. "This is alarming for anybody who takes any pharmaceutical drug."

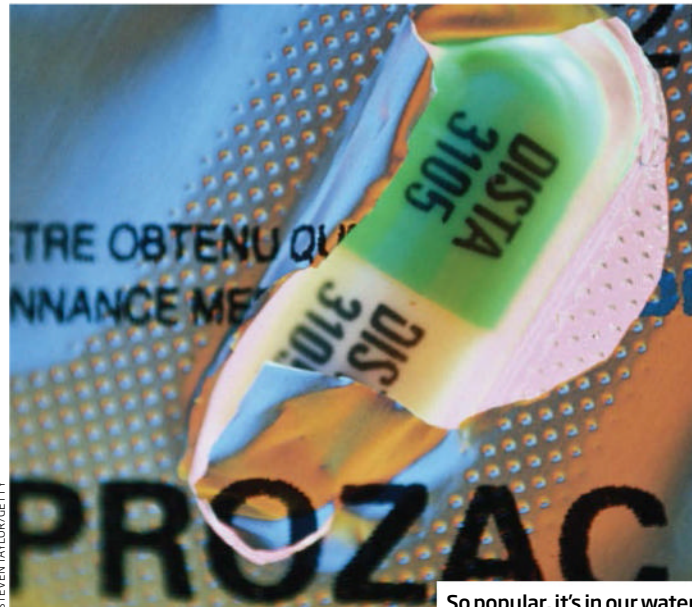
He doesn't claim that teenagers should never take SSRIs, rather that these drugs be reserved for severe depression, and that we should be alert to the side effects.

In some of the UK's poorer areas, one in six people is on an SSRI, and traces of Prozac have turned up in the water supply. So SSRIs remain in wide use despite the fact that, since GSK released its trial reports, other research has cast doubt on this group of medicines. Only this week, a study found that under-25s taking them are more likely to commit violent crime (*PLoS Medicine*, DOI: 10.1371/journal.pmed.1001875).

A major review in 2008 showed that SSRIs work no better than placebo for mild depression. Tim Kendall of the Royal College of Psychiatrists in London says a large body of evidence now shows talking therapies like cognitive behavioural therapy should be the first port of call in depression, especially for those under 30.

To GSK's credit, the firm is the only drug company so far signed up to AllTrials, a campaign for disclosure of clinical research data (see page 5).

However, Healy says that the company still makes it difficult for researchers to search and analyse its data. "If we don't have full access to the raw data we can't make out what's going on." ■



So popular, it's in our water

## Weather chaos as hottest year continues

THE forecast doesn't look good: more wild weather as the world warms fast again.

Not only is an El Niño causing record warming and altered rainfall patterns around the planet, but longer-term shifts in the Pacific and Atlantic could affect our climate for decades to come.

This could well be the end of the so-called slowdown in global warming

since the 1990s. "We are at an important turning point in Earth's climate," says Adam Scaife of the UK's Met Office, author of a new report on how the climate system is shifting. "So many big changes are happening at once."

A strong El Niño is already affecting global weather, from boosting the number of supertyphoons in the Pacific to weakening the Indian monsoon. The rain it should bring to California could ease the drought there, but with the state now missing an entire year's worth of rainfall, it is unlikely to end it.

El Niño is also bringing record temperatures as warm surface water spreads across the Pacific and releases heat into the atmosphere. This, coupled with ever-rising greenhouse gas levels, is set to make 2015 the warmest year on record – with 2016 similarly hot.

The rapid warming could continue even after the El Niño ends. A phenomenon known as the Pacific

**"2015 is set to surpass the warmest year on record, and 2016 will be similarly hot"**

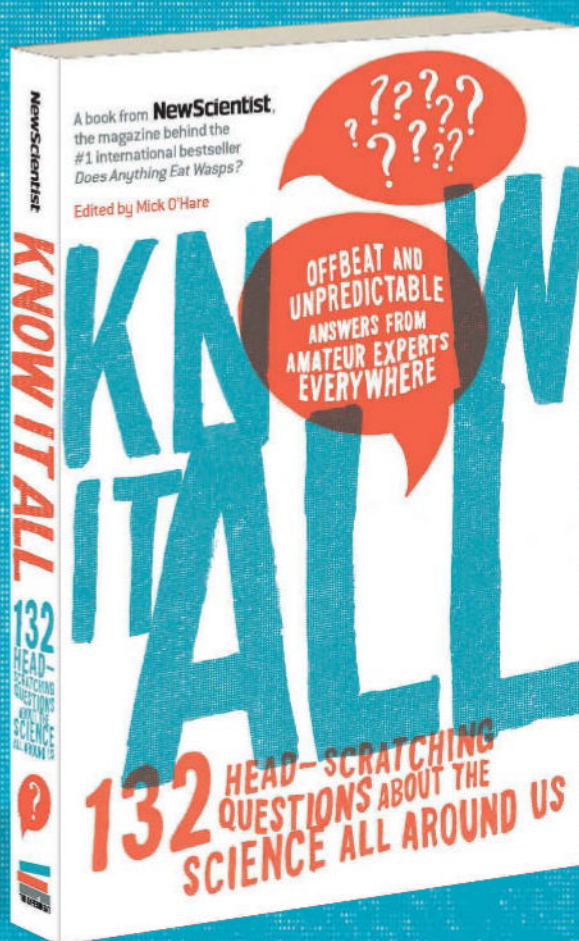
decadal oscillation is switching to a phase associated with warmer surface water temperatures across the Pacific.

Meanwhile, the deep circulation that drives warm surface waters north in the Atlantic is weakening, leading to a cooling of the north Atlantic relative to the rest of the oceans.

This doesn't mean the ocean current is about to shut down entirely – as in the apocalyptic film *The Day After Tomorrow* – says Rowan Sutton of the University of Reading, UK. But it might lead to cooler, drier summers in northern Europe for several years. Michael Le Page ■



# THE BAFFLING, TRIVIAL, CURIOUS, OR STRANGE . . . KNOW IT ALL



The latest book in New Scientist magazine's bestselling "Last Word" series presents 132 science questions and answers from amateur experts and curious minds everywhere. Find the answers to the **microscopic** (*Why do sand particles on a beach seem to reach a certain grain size and then reduce no further?*), the **puzzling** (*How did the Romans express fractions?*), the **hypothetical** (*If humans lived in a zero gravity space station away from the sun, would skin still wrinkle and sag?*), and the **practical** (*What's the best strategy for getting through multi-lane traffic jams as quickly as possible?*)—any topic is fair game!

**KNOW IT ALL: 132 Head-Scratching Questions About the Science All Around Us**  
\$14.95 • Available in trade paperback and as an ebook wherever books are sold

**A GUARDIAN TOP 10 SCIENCE AND TECHNOLOGY BOOK**

"The experts at New Scientist magazine have published a book that answers some of the oddest but most entertaining questions they've been asked."

—DAILY MAIL

"Explain[s] some of life's great mysteries."

—REVEAL

**NewScientist**



@experimentbooks  
theexperimentpublishing.com

**ALSO AVAILABLE**  
*Nothing: Surprising Insights Everywhere from Zero to Oblivion*  
\$14.95 • Available in trade paperback and as an ebook wherever books are sold





# If I wag my tail will you do it for me?

Sam Wong

PERHAPS this is why our dogs are so happy to see us. When faced with a puzzle to solve for a treat, they give up and defer to humans for help, unlike their wild cousins, wolves. So are dogs just servile beasts whose dependence on humans has made them dumber and lazier than wolves? Or is it a sign of their high social intelligence?

The answers may not be straightforward. Monique Udell at Oregon State University took 10 wolves, 10 pet dogs and 10 shelter dogs, from a variety of breeds and mixes. Then she presented them with a puzzle box containing a food reward, which could be opened with a bit of persistence.

Eight out of 10 wolves were able to open the box but only one out of 20 dogs succeeded. Most declined to attempt the task and instead looked to humans for guidance (*Biology Letters*, DOI: 10.1098/rsbl.2015.0489).

“Wolves spent almost all of their time engaged on the task trying to get the puzzle open, and dogs spent almost none. That was a pretty striking difference,” says Udell.

Even when there were no people around, dogs fared no better. They only made a

**“Wolves spent almost all of their time trying to crack open the puzzle box, dogs spent almost none”**

concerted effort to get into the box when encouraged to do so. “That gets at the key aspect here,” says Udell. “They really seem to be waiting for some indicator from humans to engage.”

So does this mean dogs are less intelligent than wolves when it comes to independent problem-solving, or just have more advanced social cognition? Udell thinks the two species have merely adopted strategies appropriate to their own lifestyle. Dogs are more inclined to solicit



Hello, I seem to be stuck

human help first, whereas wolves try to go it alone. Wolves will use humans to help solve problems when needed, while dogs' domestication and upbringing mean waiting for direction seems to be a default, Udell says.

Next, she plans to investigate genetic and lifestyle factors that might affect dogs' ability to tackle problems by themselves. For example, she says, search and rescue dogs or feral dogs may be better able to solve problems on their own than our pets.

Marc Bekoff at the University of Colorado in Boulder says we should be careful about generalising that wolves do this and dogs do that. “The incredible amount of behavioural variability among dogs makes it impossible to talk about ‘the dog,’” he says.

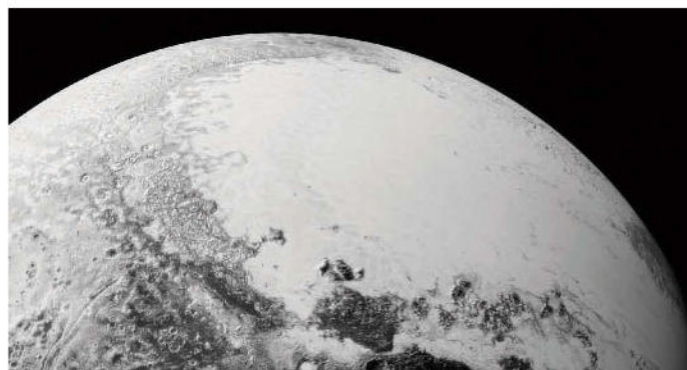
We really don't know whether dogs that look to humans for help with problem-solving have advanced social skills, making them cleverer than wolves, or are merely dependent on humans, Bekoff says. ■

## High-definition images of Pluto arrive early

THEY just couldn't wait for Christmas. The handlers of the New Horizons probe, which flew past Pluto in July, skipped a stage to get their hands on high-definition images more quickly.

The original plan was to beam back compressed versions of the Pluto fly-by pictures first, but the lure of the high-resolution images was too great to resist.

“We were always squinting at them, to try to learn about the smallest features,” says team leader Alan Stern of the Southwest



Research Institute in Boulder, Colorado.

Skipping the compressed images will also let the download finish a couple of months earlier than planned, he says.

The highlight of the high-resolution


pictures released so far is a soaring view that shows Pluto's icy north-eastern expanses (pictured). Other images feature what could be windswept dunes, glaciers of solid nitrogen and valleys that look like

they have been carved by flowing ice.

A surprise is that no moons have been discovered around Pluto besides the five already known. The team had placed bets on between one and more than a dozen new moons being found. “Nobody on the science team expected we would find zero new moons,” Stern says.

In addition to studying the Pluto fly-by data, the team is looking ahead towards a smaller icy body that they hope to steer New Horizons past in 2019. They are currently trying to gauge just how close the craft can pass by its next target in comparison to the Pluto approach. “There's a real interest in seeing if we can't go, for example, twice as close,” Stern says. Joshua Sokol ■





# A career in science, it's not always what you think

From movie advisor to science  
festival director, where will your  
science career take you?

**NewScientist Jobs**

[newscientist.com/jobs](http://newscientist.com/jobs)





## Probing the cause of diabetes, one pizza at a time

IT'S supersizing in the name of science. Volunteers who binged on burgers and pizzas may help to reveal why overeating can leave people prone to type 2 diabetes.

No one knows quite why an overly large food intake can increase someone's diabetes risk, although resistance to the hormone insulin seems to play a part.

To investigate, Guenther Boden and Salim Merali at Temple University in Philadelphia, Pennsylvania, and their colleagues fed six healthy male volunteers 6000 calories' worth of junk food every day for a week. Each was bed-bound and prevented from exercising – and

each developed insulin resistance within two days.

The team think that they know why. Over the week, the volunteers urinated larger amounts of oxidised lipid compounds. These form when reactive oxygen species attack cell membranes and are a hallmark of oxidative stress. There were signs of this stress in samples of the volunteers' fat tissue – perhaps marking the onset of the process that leads to insulin resistance, says Boden.

The oxidative stress may hamper blood-sugar regulation because it changes the structure of a protein that normally takes glucose out of the bloodstream (*Science Translational Medicine*, doi.org/7pj).

"It's a pretty cool finding," says Francis Stephens at the University of Nottingham, UK, although he thinks the volunteers will need months to shed the weight put on.

## New moonquakes in decades-old data

IT WAS there all along, but it took until now for a computer to spot it – the signature of moonquakes, hiding in seismic data from a 1970s moon landing. The technique behind the find may soon help spot tremors on Mars, too.

Seismometers left on the moon by the Apollo missions have recorded about 13,000 events: meteor strikes, deep quakes linked to the moon's orbit around

Earth, and powerful shallow quakes of unclear origin.

Software trained by humans could find even more events, says Brigitte Knapmeyer-Endrun of the Max Planck Institute for Solar System Research in Göttingen, Germany. She and her team have developed an algorithm that can identify quakes with roughly the same pattern as a sample set picked out by researchers.

When they set it to work on data from a seismometer left on the moon by Apollo 16 in 1972, they found 200 quakes that had eluded notice (*Journal of Geophysical Research: Planets*, doi.org/7m3).

The algorithm may be useful for NASA's InSight lander, which aims to put a seismometer on Mars next year. InSight doesn't have much bandwidth to send data back, so software could help determine which quakes warrant study, Knapmeyer-Endrun says.

## Ant-farmed crops look domesticated

LEAFCUTTER ants in South America's rainforests beat us to the invention of farming by 50 million years. Now it seems that their crops have undergone the same genetic changes as ours.

As people selectively bred new plants, they inadvertently made changes to their genomes. Wheat, bananas and tobacco are now polyploid – they have three or more copies of each chromosome rather than the usual two.

Pepijn Kooij's team at the University of Copenhagen in Denmark have discovered that leafcutter ant crops are the same. The fungus they farm is polyploid, while the fungi kept by less specialised ants have just two copies of each chromosome.

Polyploid plants are larger and more robust, perhaps explaining why leafcutter ant populations – like human populations – are so large (*Journal of Evolutionary Biology*, doi.org/7ph).

## Best bird parents choose their mate

TRUE love builds stronger families – at least for birds.

Malika Ihle at the Max Planck Institute for Ornithology in Germany and her team studied partner selection in zebra finches. First they organised a "speed-dating" event, allowing 160 birds to form pairs freely. They then broke up half the pairs and forced these birds to couple with a different partner.

The team found that "free" couples saw 37 per cent more fledglings successfully leave the nest than "arranged" couples.

Parental care seemed to make the difference: male partners in an arranged couple were more likely to neglect nest-care duties (*PLoS Biology*, DOI: 10.1371/journal.pbio.1002248).



## Walk this way to save energy

ANYTHING to save energy. We change our walking style on the fly when our normal gait becomes a little more difficult – a finding with implications for injury rehabilitation.

Jessica Selinger's team at Simon Fraser University in Burnaby, Canada, strapped volunteers into a lightweight robotic exoskeleton and put them on a treadmill.

The team let the volunteers find their preferred walking rhythm. They then programmed the exoskeleton to make walking at this pace more difficult by preventing the legs swinging as freely. But only at this pace – it didn't offer resistance if the volunteers walked faster or slower.

Within minutes the volunteers shifted to an awkward new walking style – even though the exoskeleton's resistance was so feeble that they made minuscule energy savings by doing so (*Current Biology*, doi.org/7pk).

Perhaps we have evolved to save energy, says Selinger. "If you look way back in time, we would have been trying to conserve as much energy as we could."

The finding suggests people recovering from injury should be reminded to experiment with new walking styles rather than trying to walk as they did before. "It might be that we need to rethink how we rehabilitate someone," she says.



## Exoplanets that support life probably look nothing like Earth

IS EARTH the odd planet out? Many of our galaxy's habitable planets might look quite different from our world.

Vardan Adibekyan of the University of Porto, Portugal, and colleagues looked at stars with a similar mass and radius to the sun that had planets orbiting in the habitable zone, where water stays liquid. They found that these stars typically contain less iron and other metals than stars that host worlds outside this zone – making our metal-rich sun unusual.

As planets are built from the

same basic material as their stars, this suggests Earth's composition might be unusual for the habitable zone ([arxiv.org/abs/1509.02429](http://arxiv.org/abs/1509.02429)).

This difference in composition between Earth and most other worlds with the potential to host life in our galaxy could be explained if planets in the habitable zone typically date from early in our galaxy's history. That's because heavy elements like iron are released when massive stars explode. When the galaxy was young, fewer stars had

died this way, so the stars and planets they bore contained less of these elements.

If habitable-zone planets are, indeed, more likely to be born orbiting metal-poor stars, that means fewer are being created now.

But the total number of planets in the habitable zone should still increase with time, Adibekyan says. This is because stars and their planets have long lives, so the small number of younger planets that have, and will be, formed in the habitable zone – like Earth – will add to a growing tally.

## New clues in battle against Alzheimer's

A CHEMICAL found in wine really does go to the brain – and might help the fight against Alzheimer's.

Resveratrol is found in grape skin and is a potential treatment for various age-related disorders. Scott Turner at Georgetown University Medical Center in Washington DC and his team tested its effects in people with mild to moderate symptoms of Alzheimer's disease. They studied 119 people; some took 1 gram of resveratrol twice a day for a year, while the others took a placebo.

The team found resveratrol in the cerebrospinal fluid, showing that it crosses the blood-brain barrier. Those who took the drug did not see the typical decline in the level of amyloid-beta protein in their blood – which is thought to be a sign that this Alzheimer's-linked compound is being deposited in the brain (*Neurology*, doi.org/7pn).

It is too early to say whether resveratrol slows the progression of Alzheimer's – but the study does suggest that it is safe to take large amounts of resveratrol for a long period of time, says molecular biologist Juan Carlos Espín of the Spanish National Research Council in Madrid.



## Birds at war over who rules the nest

IT'S a war of two tits that might have evolutionary consequences.

When great tits (*Parus major*) can't find a good place to lay their eggs, they invade the nests of the smaller blue tit (*Cyanistes caeruleus*). The blue tits usually abandon their nests: sticking around might be dangerous.

But blue tits fight strength with stealth – if they can't find a nesting spot, they will sometimes sneak their eggs into a great tit nest.

Rafael Barrientos at the University of Castilla-La Mancha in Toledo, Spain, and his colleagues found that out of 1285 nests that they studied in

central Spain, in 17 instances great tits stole the homes of blue tits and raised their chicks alongside their own. And in 17 other cases, blue tits sneaked an egg or two into the nests of great tits (*Behavioral Ecology and Sociobiology*, doi.org/7pm).

Adopted chicks might have an advantage. "Being raised by foster parents of another species may cause learning of new songs and use of new feeding niches," says biologist Tore Slagsvold at the University of Oslo. Eventually, mixed broods might even lead to hybridisation of the two species, he says.

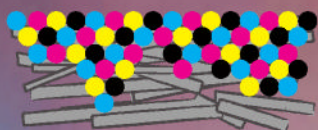


# ALL PAPER IS NOT CREATED EQUAL.

Especially in business, looking good on paper really matters. ColorLok® Technology gives paper more vivid colours, bolder blacks, and faster drying times.\* So make a strong impression by choosing paper with the ColorLok logo. [Learn more at colorlok.com](http://colorlok.com)

## THE SCIENCE OF WOWING YOUR CUSTOMERS

ColorLok Technology turns everyday office paper into your canvas for eye-popping imagery and incredibly professional presentations. How? By injecting additives during the paper-making process that enable the paper to "lock" pigments at the surface. Without this technology, paper acts more like a sponge, absorbing black and colour pigments deep into the fibres of the paper and away from the surface.



Without ColorLok Technology, pigment sinks deep into the paper's fibres. Black appears duller and colours less vibrant.



When you print on paper with ColorLok Technology, the additives within the paper react with the pigments, keeping colour near the surface for bold, vivid results.

## A NEW LOOK FOR ECO-FRIENDLY PAPER

Even recyclable paper looks better than ever, because ColorLok Technology creates a shield between the surface and subsurface fibres. Printouts on recycled paper can now retain a brighter, richer appearance, so you can be eco-friendly without compromising quality. What's more, paper with ColorLok Technology is actually easier to recycle. So yes, you can look good and do good.

© Copyright 2015 HP Development Company, L.P. The information contained herein is subject to change without notice.

\*Independent testing by SpencerLab Digital Color Laboratory, commissioned by HP. The full October 2009 report, "Print Quality Analyses - ColorLok Media Evaluation: AIO Printers: Brother MFC-5490CN, Canon PIXMA MX860 & MX7600, Epson WorkForce 600, HP OfficeJet 6500 and OfficeJet Pro 8500," is available for download at [spencerlab.com](http://spencerlab.com)





## VIVID COLOURS

Richer, brighter  
images and graphics  
on all your printers



## BOLDER BLACKS

Means crisper, sharper  
text and lines than with  
standard paper



## FASTER DRYING

Less smear and faster  
handling compared  
to papers without  
ColorLok Technology



## ECO-FRIENDLY

Easier to recycle,  
with results that  
don't look dull



## CONSISTENCY

Consistent and reliable  
printing regardless of  
which machine is used







BOEING

Autonomous, and staying that way

# Can't hack this

Securing just a small chunk of a computer's software can keep the world safe from devastating cyberattacks, says **Michael Slezak**

AN AUTONOMOUS helicopter gunship is flying over a military base in Arizona. Suddenly, officers on the ground lose radio contact: hackers have taken control of an on-board computer. Could they fly the helicopter?

This has happened – well, almost. *New Scientist* can reveal that the US Defense Advanced Research Projects Agency (DARPA) used this scenario in a drill to test the cybersecurity of an uncrewed Boeing Little Bird helicopter.

Despite the hackers being given unfettered access to the computer, and then trying their hardest to disable the helicopter – even crashing the computer – they could not disrupt critical systems. For DARPA, which is aiming to develop an “unhackable” drone by 2018 as part of its High-Assurance Cyber Military Systems (HACMS) programme, the drill was a success.

This isn't just about the military, though. The software that kept the helicopter's computer secure was at the heart of its operating system, and it could be just what the world needs to make everything from pacemakers to insulin pumps and power stations to cars immune to hacking.

“My hope is that in 10 years' time, anything that is security critical is running on our system or some other one built on the principles we've established,” says Gernot Heiser from the newly formed Australian national research agency, Data61. One of its predecessors developed the crucial component of the “unhackable” operating system – its kernel.

The kernel is the central core of any computer's operating system. If hackers gain access to it, they can perform actions that are meant to be forbidden – like turning a mobile phone into a

signal jammer, for example. Last year, Heiser's team proved mathematically that their kernel is unhackable.

Known as seL4, the kernel has a few highly secure properties: it can only do what it is designed to do; its code can't be changed without permission; and its memory and data transfers can't be read without permission. An

**“Car hackers may access the entertainment system and use it as a springboard to a critical area like steering”**

earlier version of it, called OKL4, is now in millions of smartphones.

Heiser says that two features underpin seL4's security, one of which is a new way of isolating data inside the kernel. But the key development was making the code capable of being checked mathematically. Other kernels

might have these properties too, but it is impossible to know for sure without mathematical proof, says Heiser.

In July, two hackers pulled a prank by remotely accessing the computer of a Chrysler Jeep, making it stop suddenly on a highway and then crash into a ditch. As a result, the company recalled 1.4 million vehicles. Could seL4 prevent such episodes in the future?

## No more break-ins

Heiser says you can't stop hackers getting access to things like a car's entertainment system, if it communicates using Wi-Fi. And hackers often use a non-critical system as a springboard to critical areas like steering – as happened with the Jeep prank. But the seL4 kernel can keep systems separate, Heiser says. “There are now efforts afoot to roll this out to cars to protect them.”

That's what the helicopter drill demonstrated. On the assumption that not every system can be made secure, the organisers made one computer run two operating systems simultaneously, one of which included the seL4 kernel. They then gave hackers full access to the other system.

“In the past they had no problem owning that thing. But we can now stop them from breaking in,” says Heiser.

The same principles will apply in preventing hackers from gaining access to critical systems in power grids or medical devices, says Kathleen Fisher at Tufts University in Medford, who is also the HACMS programme manager.

It is a big deal for cybersecurity, says Iman Shames from the University of Melbourne in Australia. But he says there are always ways to attack hardware, even if the software is impregnable. Hackers might be able to spoof a device's sensors or jam incoming communications or other signals, which could be just as devastating. ■



# What will you buy next? The computer knows

DON'T pretend you don't want that chocolate bar. Software can now sense how much you've been swayed by marketing just by analysing your face as you watch advertisements.

Ad companies are often interested in gauging consumers' reactions to their latest TV spot. Traditionally, this is done by bringing a few customers into an office and asking questions.

But the system made by Affectiva, a start-up in Waltham, Massachusetts, can pick up on hidden emotions just by monitoring face movements. The approach, says Affectiva's principal scientist Daniel McDuff, lets you find out what people actually think from moment to moment while the ad runs, not just what they say once it is over.

"It provides a way of getting at those more genuine, spontaneous interactions," he says. "This is their visceral response. It's not sent through

a cognitive filter where they have to evaluate how they feel."

Affectiva's software first pinpoints important facial markers, such as the mouth, eyebrows and the tip of the nose. Then, machine-learning algorithms watch how those regions move or how the skin texture and colour changes over the course of the

**"You could imagine suggesting movies that people could watch, or ads that they find enjoyable"**

video. These changes are broken down into discrete expressions indicating shifting emotions.

In a study published this month, McDuff and his colleagues asked 1223 people to give his team access to their home webcams while they watched a series of ads for sweets, pet supplies

and groceries. Before and after the ads ran, the subjects filled out online surveys about how likely they were to purchase the products shown. While they watched, the software stayed on the lookout for emotions, such as happiness, surprise or confusion.

Afterwards, the researchers found that they could use the facial data to accurately predict someone's survey results - suggesting that they could rely on the computer's analysis alone to know whether an ad was successful (*IEEE Transactions on Affective Computing*, doi.org/7mm).

In the future, McDuff thinks the system could plug into TV services such as Netflix. "You could imagine suggesting TV programmes or movies that people could watch, or ads that they find more enjoyable," he says.

The Affectiva team has amassed a database of over three million videos of people across different ages, genders and ethnicities. McDuff says that there seem to be subtle variations in emotional responses: women tend to have more positive facial expressions than men, for example. By understanding how different groups respond, companies could put together ads that are fine-tuned for particular audiences.

The data could also help advertisers to tweak their adverts to tie in more closely to viewers' emotions - for example, by putting in the name of the brand at the moment that elicits the strongest positive reaction.

Automated emotion analysis systems are promising, says Michel Wedel, who studies consumer science at the University of Maryland in College Park. They let advertisers break an ad down moment by moment, to figure out exactly what works and what doesn't.

"What's particularly powerful is that they're unobtrusive," he says. "They don't rely on introspection or recollection."

Being able to do research through viewers' home webcams is another advantage, says Wedel, although it won't be foolproof. "People could be at the computer eating a sandwich or turning their head, so it could be the case that you can't classify their emotions reliably." Aviva Rutkin ■

## ONE PER CENT



### Control a drone swarm

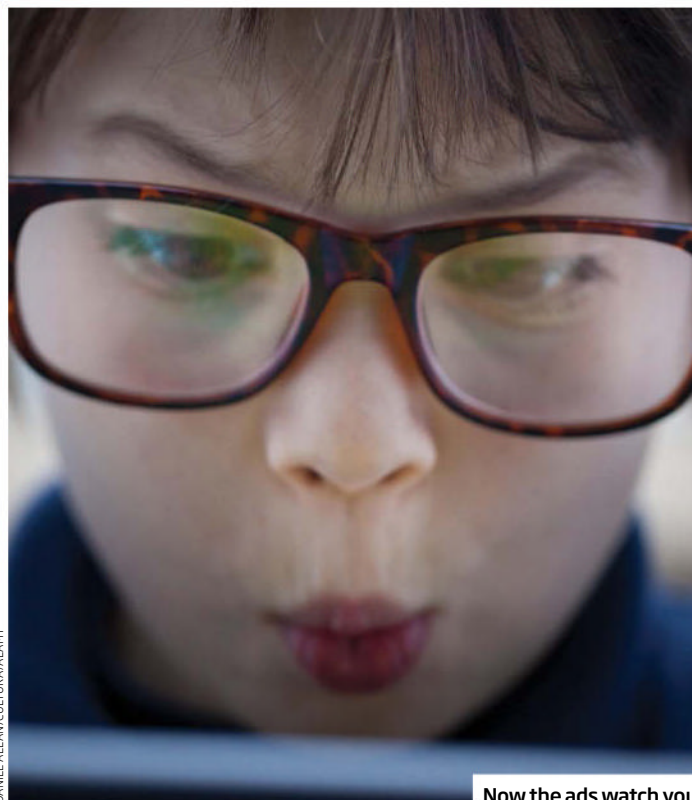
Up, up and away. A team at the Naval Postgraduate School in Monterey, California, has succeeded in launching 50 small drones that were all controlled by a single person - believed to be a world record. To launch them, the team developed a chain-driven launcher that fires off one drone every 30 seconds. Once airborne, the drones communicate with each other via Wi-Fi.

**"Which part of a plant produces the seeds? (A) flower (B) leaves (C) stem (D) roots"**

A high school exam questions that an AI called Aristo can answer. The team at the Allen Institute for Artificial Intelligence in California wants to use school tests to benchmark how much AI knows

### A robo-hack writes

The bots are coming. Asian tech giant Tencent has unveiled an automated reporter. Dreamwriter published its first story on the Chinese social network QQ, a 916-word report on August's consumer price index, plus economic analysis. The process took about a minute. "I can't even tell it wasn't written by a person," human reporter Li Wei told the *South China Morning Post*.



Now the ads watch you



Think, and it happens

# Thought control hits home

Smart homes controlled with your mind promise more independence, says **Jessica Hamzelou**

FEELING cold? Your home already knows, and turns up the heat. Sick of the TV show you are watching? Your home changes the channel. No need for a remote controller, just think about what you want and it will happen.

Smart homes fitted out with remotely controlled appliances are already here, and thoughts have been used to control aspects of a virtual reality home. Now Eda Akman Aydin at Gazi University in Turkey and her team are attempting to combine the two.

The aim is to improve the home environment for people with movement disabilities, says Akman Aydin, allowing more control and independence. They have developed a system in which people use their thoughts to select from a menu on a screen.

The group use an EEG cap to

pick up a signal known as a P300 – a pattern of brain activity that appears when a person intends to do something. An accompanying display shows a list of representative images, for the television, phone and air conditioning, for example.

**“All the volunteers learned to control the TV. They could choose a film and change the volume”**

The idea is that when a person wants to use the phone, and sees an image of a phone, their brain will create a P300 signal. A smart home can respond by preparing the phone to dial a number, via a wireless internet connection.

When Akman Aydin and her colleagues tested their device with five volunteers, all were

able to learn to control a phone, light, TV and heater. “They could choose a film and change the volume,” she says.

Five flashes of an image were enough to pick up the correct P300 signal at least 95 per cent of the time for all five people, and two people were successful 100 per cent of the time. Akman Aydin presented her results at the IEEE Engineering in Medicine and Biology Society meeting in Milan, Italy, last month.

EEG is not the only approach. Takeshi Ogawa at the Advanced Telecommunication Research Institute in Kyoto, Japan, is instead using a type of brain scan called functional near-infrared spectroscopy. A cap shines laser light onto the head, and this lights up blood vessels close to the surface of the brain. Light passing through the vessels is measured to give an indication of which areas are actively using oxygen.

The group asked three volunteers to try out their system in a real smart home environment. Controlling the TV meant activating the part of the brain involved in movement, so the volunteers were asked to move a limb. “The system got it right 80 per cent of the time,” says Ogawa, who presented his work at the same meeting.

But because the system relies on adapting to changes in blood in the brain, it takes a while to respond. “The problem is that you wave your arm but you can’t watch TV until 17 seconds later,” he says.

He wants to develop a quicker and more sensitive system that can pick up subtle changes in brain activity that are associated with thoughts of movement and so would not require the user to move.

Both approaches hold promise, says Nicholas Hatsopoulos at the University of Chicago. “They indicate a future in which brain-machine interfaces are connected to almost everything in the house,” he says. ■

## The social network where it literally pays to post

**SOCIAL media:** it’s the ultimate timewaster. But what if you could earn cash for the hours spent highlighting the posts you like?

Gaption is giving it a shot. The app, created by a team based in Kuala Lumpur, Malaysia, pays all users a portion of its profits. “The idea is to share success with people,” says co-founder Kenneth Ho.

Gaption looks like a cross between Facebook and Instagram: a mixture of photos, short text posts and links to web stories. It also carries ads for products and services offered by users, who may be small business owners, musicians or artists. When they make a sale, Gaption takes a cut and pays some of it to other users who have reshared or liked the relevant ad.

To work out how to split the money, its servers crunch the numbers for every post based on an ad: how well connected the poster is, how many people liked or shared the post, and how many clicked through on the ad.

Depending on the post, Ho says, Gaption keeps between 50 and 80 per cent of the revenue. Typical users currently earn up to a few dollars per week. Each user has a personal online account from which they can withdraw funds or pay for what other users are advertising for sale.

Since its launch in June, Gaption has gained over 20,000 users, mostly in the US and the UK. Aviva Rutkin ■



This one's just for kudos



# LOOK FOR YOUR HERO

— ON —  
NEW SCIENTIST  
CONNECT

Find your hero (or heroine)  
on New Scientist Connect -  
there are plenty to choose from.

Meet like-minded people who  
share similar interests to you  
- whether you're looking for love,  
or just to meet someone on  
the same wavelength, no matter  
where you are in the world.

Start your search now at:  
<http://dating.newscientist.com>

*Join now*  
**FOR  
FREE**











## Living fossil re-emerges

ALMOST 30 years had passed since the last sighting of *Allonautilus scrobiculatus* when this creature swam in front of Peter Ward's camera last month, deep below the sea off Papua New Guinea.

Nautiluses, distant relatives of squid and cuttlefish, are sometimes called "living fossils" because they appear almost unchanged from 500-million-year-old preserved specimens.

Ward, who is a biologist at the University of Washington in Seattle, and his colleague Bruce Saunders first described *A. scrobiculatus* in 1984. Its shell shape looks unwieldy compared with the more streamlined shells of other animals in the Nautilidae family, but it appears to have evolved that way relatively recently. "It turned on its head what we thought of as primitive," says Ward.

Finding them is an immense challenge. To get this snap, Ward's team used specialised cameras that were lowered down 200 metres along with fish or chicken meat as bait. *A. scrobiculatus* can only survive within a narrow depth range, and may only exist in a handful of locations. Four of the creatures had radio transmitters attached to them so Ward's team could track them (see below).

Now some fear that its habitat might be under threat - ironically, by a company that bears its name. Nautilus Minerals, based in Toronto, Canada, has been granted a permit by the Papua New Guinea government to begin mining deep-sea hydrothermal vents in the area. NGOs and environmental groups are campaigning against the project. Sam Wong



### Photographer

Peter Ward



# Compassion's wake-up call

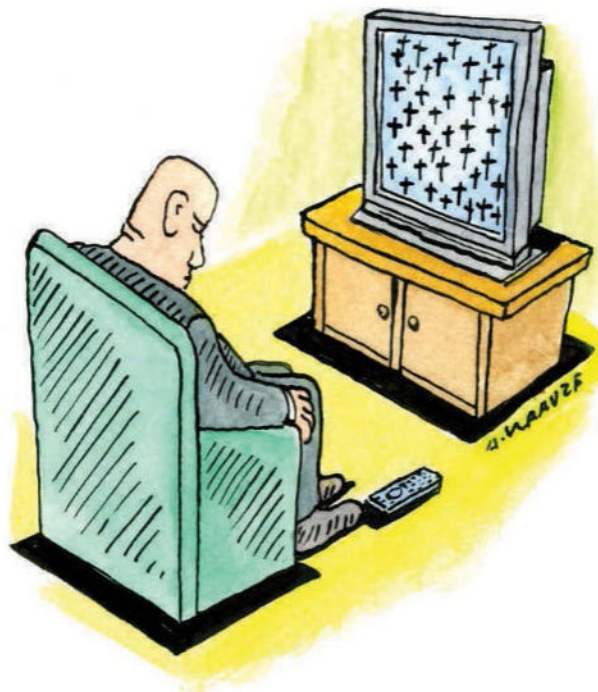
It took a dead child's image to end apathy to mass refugee deaths on Europe's shores. It doesn't have to be this way, says **Daryl Cameron**

THIS summer has been marked by apathy and hostility to refugees in Europe, despite many drowning in the Mediterranean while trying to reach the continent.

Then the public mood suddenly changed. The catalyst was an image of one Syrian boy who died in the sea trying to reach Greece.

That a lone tragedy energised sympathy for refugees, when the deaths of many had not, seems odd, but this numbness to large-scale disaster is borne out by psychological research: studies show we feel strongly and are more willing to donate for single identifiable victims.

Why? Some scholars say it happens because we simply can't feel compassion for large groups. As psychologist Paul Bloom puts it: "It is impossible to empathise with 7 billion strangers, or to feel toward someone you've never met the degree of concern you feel



for a child, a friend, or a lover."

Fellow US psychologist Paul Slovic also argues that "our capacity to feel sympathy for people in need is limited, leading to compassion fatigue, apathy and inaction".

If empathy and compassion are fundamentally insensitive to large-scale problems, this seems to speak poorly for the usefulness of these moral emotions. But what if callousness to mass suffering represents a choice, and not a constraint beyond our control?

People actually predict they will feel more compassion as victim numbers increase. Yet this may in turn stoke up worries about the financial and emotional costs of trying to help many. Maybe this will be too expensive, ineffective given the scale, or too emotionally excruciating to think about.

For these reasons, people might try to suppress emotions such as sympathy to avoid these costs.

## Spread the happy

Consumer pressure is making an agricultural villain mend its ways, says **Curtis Abraham**

RARELY has a variant of a standard nutrient been as vilified as palm oil, aka the killer of rainforests, destroyer of communities and warmer of the world – slurs that are occasionally justified. But this villain is being rehabilitated.

Bad reputations are hard to shake off, however. Witness the potshot taken by Ségolène Royal,

France's minister of ecology, sustainable development and energy, against a popular hazelnut chocolate spread. "We should stop eating Nutella... because it's made with palm oil," she declared on TV, equating the oil with rainforest destruction.

Royal was perhaps unaware that consumer campaigns by

conservation bodies and human rights organisations have caused some oil-palm growers and food producers to clean up their act; a clear example of the power of campaign groups and shoppers to challenge activity that damages the planet in distant countries.

Italian company Ferrero, maker of Nutella, said last year that it only uses oil with Sustainable Palm Oil Segregated Certification, meaning that products are now produced solely with oil produced

**"Conservation campaigns have seen consumers pressure oil palm growers to clean up their act"**

sustainably and ethically.

Last year the US food firm Kellogg's also bowed to public pressure, announcing it would only buy palm oil from companies that don't destroy tropical rainforests to make way for palm plantations. And since January 2012, 75 per cent of the palm oil that food company Nestlé UK uses has been traceable to plantations certified by the Roundtable on Sustainable Palm Oil. The other 25 per cent is bought via GreenPalm – a scheme that boosts sustainable producers.

In 2010, consumer goods firm Unilever listened to the demands of tens of thousands of consumers



Research in my laboratory backs this up. Volunteers saw images of either one or eight child refugees from the Darfur region of Sudan. Half were told to expect a request for a financial donation later. We found that the collapse of compassion from one to many victims reversed when this cost expectation was removed.

We may put emotional blinkers on consciously or instinctively. But if we realise we are tuning out mass suffering in our own self-interest, perhaps we can do something about it. There is a body of work in psychology and neuroscience that finds apparent limits of compassion and empathy can be overcome.

Presenting unsettling pictures of identifiable victims may not be the only way to inspire pro-social action in the face of large-scale crises. Instead, we can ask why people are failing to respond and target motivations for this. If they worry about emotional overload or the cost of intervention, then we can try to relieve those fears. My lab is pursuing ways to do this.

Although people often lack compassion for mass suffering, indifference is not inevitable. ■

Daryl Cameron heads the Morality Lab at the University of Iowa and studies psychological and brain sciences

to source sustainably produced palm oil, and is committed to purchasing all of its palm oil from such sources by the end of 2015.

The push for ethically sourced palm oil has come mainly from the European Union. There is still a long road ahead for consumer advocacy in other Western countries and other major importers of palm oil such as China and India.

Royal, realising her gaffe, and in a move that would surely please the ambassador, offered Ferrero “a thousand apologies”. ■

Curtis Abraham is a journalist based in East Africa

## ONE MINUTE INTERVIEW

# Monster trucks to the stars

Arranging 100-tonne antennas into a vast telescope in the desert requires a huge transporter. **Alfredo Alvarez** is driving



### PROFILE

Alfredo Alvarez is an operator and mechanic for the transporters used to move and set up the antennas of the Atacama Large Millimeter/submillimeter Array (ALMA), a telescope in the Atacama desert plateau in Chile

### How did you get to drive these behemoths?

I started operating simple machines like front loaders and mining trucks 10 years ago. Then I got a degree in heavy-duty mechanics and went on to work as a mechanic on ALMA's two transporters, Otto and Lore. They are 20 metres long, 10 metres wide and weigh 130 tonnes. After two years I was promoted to operator. Four of us do all the repairs and maintenance of the machines.

### You work high up in Chile's Atacama desert. What tasks do the transporters typically do?

ALMA has 66 dish antennas, each 12 metres in diameter and weighing over 100 tonnes. We recently picked the last one up from the operations support facility at 2900 metres altitude. We loaded the antenna in the morning and drove 28 kilometres to the Chajnantor plateau at 5000 metres altitude, to complete the array. It took 7 hours, partly because we can only go at 5 kilometres per hour when laden, and partly because we had a hydraulic leak that needed fixing along the way. We have placed the

antennas in a long-base configuration for now, with the outermost ones in the array 16 kilometres away from each other.

### How do you control these complex vehicles?

Each one has 11 computers on board, four of them purely for the very sophisticated steering system. The transporter is U-shaped and has 14 pairs of tyres, and the computers need to know the relative angles and heights of the axles, the slope of the road and whether there's an antenna being carried. I can also stand outside the transporter and operate it by remote control when I need a different view.

### What's it like working with such a machine?

I feel very connected to it, like with my motorcycle. I'm used to its noises, smells and reactions. When something is wrong I can sense it. You build up a relationship with what should be, and you notice right away when it's not doing what it's supposed to. It reminds me of a living thing, with 1200 litres of hydraulic fluid instead of blood.

### Do you know how much the antennas cost?

I have no idea – that would just be more stress. They are really delicate, expensive things, so you have to be very careful and focused. For me, trying not to think too much works best.

### Does the altitude cause you problems?

No, I'm used to it. I move a lot, up and down ladders, getting tools, helping the other guys. The back of the driver's seat is designed to allow me to wear an oxygen tank, but I don't because it's uncomfortable and I've never felt any ill effects.

### How do you unwind in this remote outpost?

During the week, I play music mainly. I'm a drummer. We have a rehearsal room and I go over there and practise most nights. When I get time off I live on my motorcycle. I do a route around here in Chile or around Peru. I go nomad all over the place, but it's with these machines that I feel at home.

**Interview by Hal Hodson**



# It takes two... but why? Blame an ancient hook-up

Sex might be everywhere, but we still don't know why animals and plants do it. **Justin Havird** has a new take on this old conundrum

SEX seems to be everywhere we look – on billboards, TV and in every corner of the internet. It is pervasive in nature too. Almost all animals, plants and fungi partake in it. Despite this, sex has mystified biologists from the time of Darwin to the present day.

Sex is a puzzle because it makes far more sense to produce clones. Why go to all the trouble of finding a mate if you can make offspring asexually? An asexual organism can produce many more offspring than a sexual one, which must find a partner and only passes on half of its DNA. This twofold cost of sex means that, in theory, asexuals should quickly replace sexuals in a population. So why doesn't this happen? I decided to wade into this contentious area.

## Adaptation isn't enough

There are many theories about why sex evolved. Did it originate as a mechanism for organisms to evade being eaten from within by parasites, or to better adapt to environmental changes? One thing most of these theories hinge on is that sex offers a great benefit: the reshuffling of genetic information into novel combinations, helping organisms adapt. It can also help spread beneficial mutations throughout a population and eliminate harmful ones.

But as explanations for sex, these fall short in two key ways. If genetic recombination is so beneficial that all eukaryotes – organisms, including animals and plants, with complex cells that contain a nucleus – have sex, why is it that prokaryotes (simple, single-celled bacteria and archaea) never evolved to do so? Conversely, because of the costs associated with sex, natural selection ought to favour

asexual reproduction – so why are eukaryotes so reliant on sex?

The answer might lie in a fundamental difference between the eukaryotes and prokaryotes: mitochondria. They provide the vast amount of energy needed to power cellular functions, and are found exclusively in eukaryotic cells. I, together with evolutionary biologists Damian Dowling and Matthew Hall of Monash University in Melbourne, Australia, argue that this is no coincidence, and that the acquisition of mitochondria made the evolution of sex an absolute inevitability in eukaryotes (*BioEssays*, vol 37, p 951).

Life on Earth originated about 4 billion years ago, but remained simple for the first 2 billion years, when the only living things were prokaryotes. Then eukaryotes came on the scene. The details of how this happened are still the subject of research, but most biologists now agree that eukaryotes arose when one prokaryote engulfed another in a symbiotic relationship. Over millions of years, this lineage would give rise to all Earth's eukaryotes.

Even today, the signature of this interaction is manifest in us all, and each partner in this symbiosis has retained its own genetic material. Essentially, one symbiont gave rise to the genome within the cell nucleus, while the other became our mitochondria, which house their own genome.

Despite its small size, the mitochondrial genome is critical for eukaryotic life, but it can't do anything by itself. It can't make energy, produce proteins or even replicate its DNA without lots of help from proteins that are encoded by the nuclear genome. For example, the machinery of the cell's electron

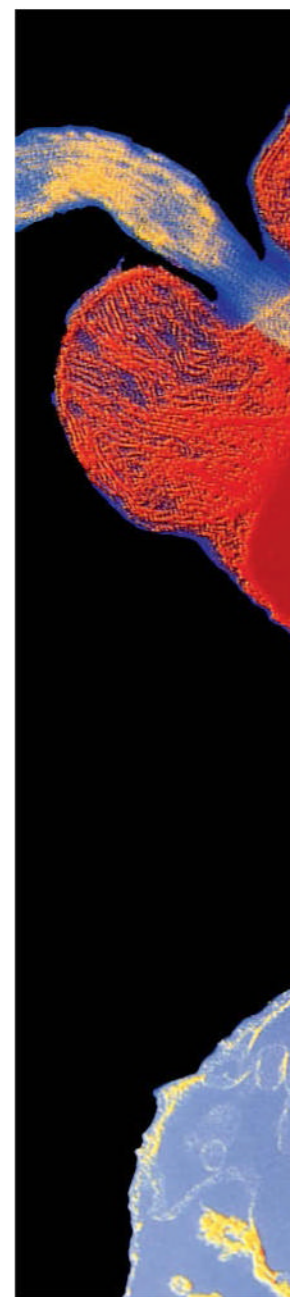
## PROFILE

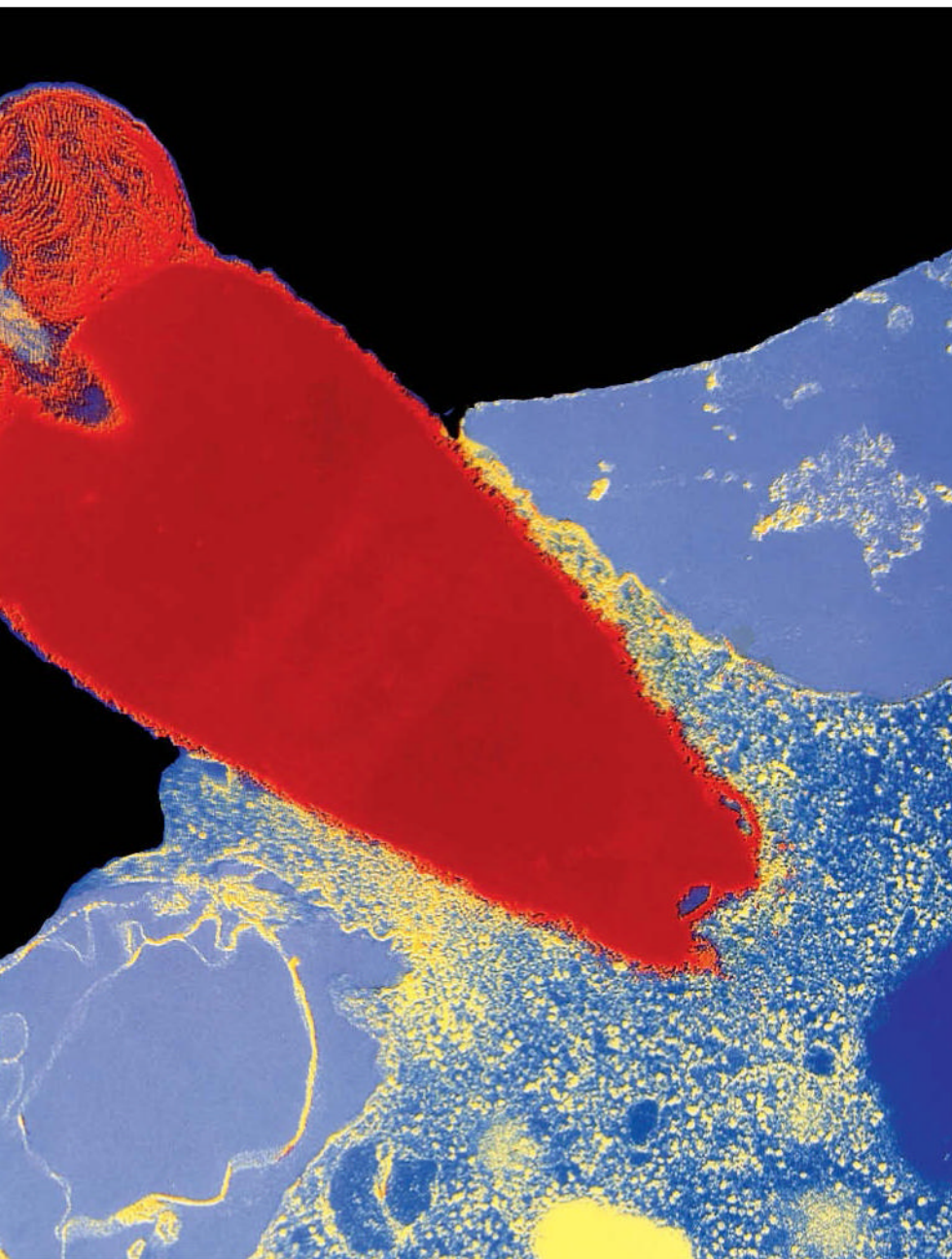
Justin Havird, an evolutionary biologist at Colorado State University in Fort Collins, researches how the cell's two genomes work together. Find out more at [jchavird.wix.com/jchavird](http://jchavird.wix.com/jchavird)

**Sperm meets egg: did this evolve to cope with problems elsewhere in the cell?**

transport system, which creates cellular fuel, is made of proteins encoded by both the mitochondrial and nuclear genomes. Maintaining the interactions between the two sets of proteins is essential for energy generation and life as we know it.

This is where our theory about sex comes in. We think that sex was an ingenious way to maintain protein interactions in the face of a certain breakdown in mitochondrial function. This breakdown is inevitable because the mitochondrial genome accumulates





mutations at a higher rate than the nuclear genome – about 10 times as fast in mammals, for example. This means that nuclear proteins will always be playing catch-up with the ever-changing mitochondrial proteins, trying to offset mitochondrial mutations that would otherwise be harmful without a nuclear counterattack. We contend that sex, and its associated trick of genetic recombination, levels the playing field by providing novel combinations of nuclear genes.

According to our model, these new genetic

variants are “screened” by natural selection for their ability to offset changes in the mitochondrial genome. In other words, if new nuclear genetic combinations provide a better match to the mitochondrial proteins, they will spread throughout the population due to natural selection, while those that present a significant mismatch will be purged.

What is the evidence for our idea that mitochondrial mutational meltdown drove the evolution of sex? No direct studies have examined this, but the concept of

“mitonuclear match”, which describes how the nuclear genomes of a population or species have adapted to the mitochondrial genome, provides indirect support.

Studies of mammals, arthropods and yeast provide plenty of support for the related concept of mitonuclear “mismatch”.

## “Why make the effort to find a mate to reproduce, when you can generate clones?”

For example, when we genetically modify organisms to express a foreign mitochondrial genome alongside their native nuclear genome, we see inefficient energy production, reduced reproduction and even death. Since mismatch leads to disaster, a mechanism to avoid it is crucial, and our hypothesis provides this.

### Plant-based test bed

Other evidence comes from the observation that plants, which generally have low rates of mitochondrial mutations, are also less reliant on sex. In May I went to Greece to collect seeds and tissue from several species of the plant genus *Silene*. These plants are useful experimentally as closely related species vary widely in their mitochondrial mutation rates, so they can be used to test the effects of these mutations on the nucleus. Another way to test our hypothesis would be to see whether mitonuclear mismatch and sexual reproduction are correlated.

It is too early to tell whether our hypothesis is correct, but there is likely to be more than one driver for the origin of sex. We argue it's a safe bet that it was tied to the emergence of the eukaryotes (and hence to the origin of mitochondria), although this will no doubt be debated for many years. Our theory doesn't conflict with previous ones: genetic recombination also provides ways to adapt to parasites and the environment.

Our work highlights the importance of mitochondria and mitonuclear interactions in shaping complex life on Earth. Mitonuclear interactions have been used to account for processes as diverse as speciation and ageing. Sex is only one of many mysteries that mitochondria will probably shed light on. ■

Find out more about how evolution has shaped sex at *New Scientist's* lecture in Melbourne, Australia, on 1 October. See [bit.ly/evosexlive](http://bit.ly/evosexlive) for more details and tickets

EVERETT ANDERSON/SCIENCE PHOTO LIBRARY



# Out with the old

Could purging worn-out cells be all that it takes to stay healthy as you age?

Jessica Hamzelou reports

**E**VER wanted to be immortal? Be careful what you wish for. Living forever wouldn't just mean outliving your friends, family and descendants, there's also the inconvenient reality of ageing. Beyond the superficial stuff, such as wrinkles and saggy bits, you'd have a host of age-related diseases to contend with. The older we get, the greater our chances of developing cancer, heart disease, Alzheimer's and almost every other common condition. Meanwhile our immune system wears out and puts up an increasingly weak defence against infections. Who wants to endure millennia of that? No thanks!

But imagine you could live a long life and remain healthy right to the end. That surely would be worth wishing for. Scientists have been seeking ways to achieve this. Now they might just have found one.

The discovery has raised the tantalising possibility that we could strike at every age-related disease with a single blow. "That's the dream," says Judith Campisi at the Buck Institute for Research on Aging in Novato, California. "It would revolutionise the way medicine is practised." Instead of seeing separate specialists for heart disorders, cancer and dementia, a single doctor would take a more holistic, preventive approach to your health.

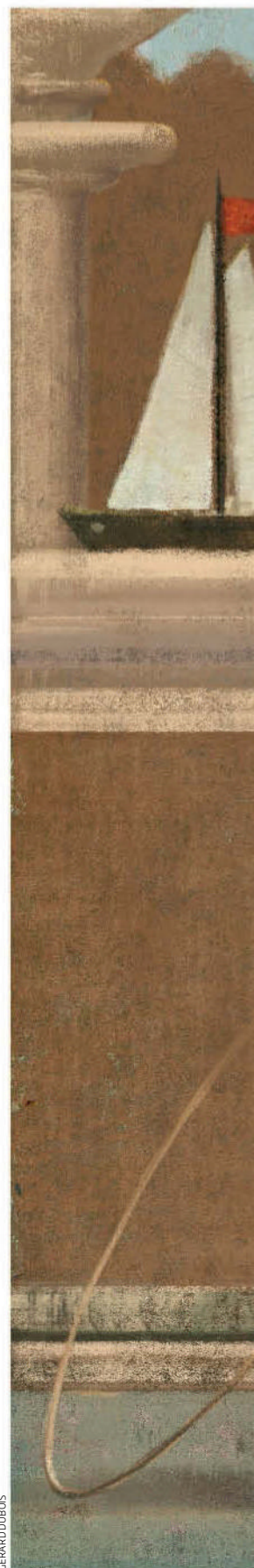
But there are philosophical and practical implications. Should we treat ageing as an illness that can be seen off with drugs? If we extend our years of good health, will we live longer too? What consequences will that have for individuals and society? And what will we ultimately die of?

The key to this improbable-sounding elixir of youth lies in targeting old, worn-out cells. Young organs are full of cells that divide to replace damaged neighbours. But each only divides a finite number of times. After that they might not die, but instead enter a state called senescence, in which they get bigger and flatter and undergo chemical changes (see diagram, page 33). The same fate awaits cells damaged or stressed by free radicals, reactive molecules created when cells metabolise. Senescent cells gradually accumulate as we get older, says Campisi, who studies them. "We've seen them in every organ we've looked at." Until a few years ago, researchers weren't sure what these cells were doing. Now, they believe the cells have a pivotal role in ageing.

## Here comes trouble

Although they can't divide, senescent cells do pump out a slew of proteins and other compounds that cause inflammation, an immune response that can damage healthy cells. As we grow older, and more and more of our cells senesce, the inflammation becomes chronic. Pretty much every age-related disease we know of involves inflammation: so far, researchers have found evidence of a link to muscle wasting, cataracts and glaucoma, Alzheimer's and Parkinson's, osteoporosis and arthritis, heart failure and high blood pressure, cancers, and lung, liver, kidney and skin disorders.

So senescent cells look like trouble. Can we get rid of them? In 2011, Darren Baker at the Mayo Clinic in Rochester, Minnesota, and ➤









## “Treated mice were stronger in old age, and looked younger with plumper, less wrinkled skin”

his colleagues did just that. They genetically engineered mice so that senescing cells would carry a tag marking them out as targets for a drug capable of destroying them.

Administering the drug every few days to mice from the age of three weeks significantly delayed the onset of age-related conditions such as hunchback and cataracts. These individuals were also stronger in old age than their untreated counterparts, and looked younger with plumper, less wrinkled skin. Baker's team saw similar benefits when they gave the drug to mice already starting to show the signs of age.

It's one thing to delay ageing in rodents, quite another to do it in people. We can't genetically engineer humans to label their senescent cells. Nor can we turn these cells back into happily dividing ones – as far as anyone knows, senescence is irreversible.

In any case, we wouldn't want to stop senescence completely because it appears to have some useful functions. Cells that have become cancerous are usually fast-tracked to senescence, stopping them from dividing further to form a tumour, and the compounds they subsequently release may trigger other cells to repair damaged tissue. Senescent cells may also play a part in wound healing and embryo development, says Thomas von Zglinicki at Newcastle University in the UK.

What to do? One alternative is to stop the cells pumping out their toxic chemical brew. This may be possible using existing drugs. Rapamycin, which helps prevent tissue rejection following an organ transplant, is known to expand the lifespan of mice by around 10 per cent. In July, Campisi's team

tested it on samples of senescent human cells and found that it lowered the production of inflammation-causing proteins. There's a snag here too, though. Rapamycin is useful in organ transplants because it weakens the immune system, but that means it leaves people more susceptible to disease. The drug has also been linked with an increased risk of diabetes.

Some research groups are trying to find safer alternatives. Campisi and her colleagues have formed a company to screen drug databases for compounds that might have the same effect as rapamycin. “We have some hits, but it's hard to predict what will make it into the clinic, although we're optimistic,” she says. Meanwhile, a team led by Joan Mannick at Novartis Institutes for BioMedical Research in Cambridge, Massachusetts, has found that a drug similar to rapamycin appears to boost the immune system, rather than weakening it. She doesn't know if the drug is safer than rapamycin, but is planning further tests to find out.

### Pill of youth

This area of research is developing rapidly. But any treatment targeting the inflammatory chemicals pumped out by senescent cells would need to be taken regularly, and that is hard to justify in otherwise healthy people, no matter how safe the drug. A better option might be to periodically clear out senescent cells to limit the damage they cause. “We know from our mouse model that senescent cells accumulate slowly over time,” says Campisi. “You could take a drug to wipe them out every five years, for example.” Such a treatment

would probably begin at around the age of 50, which is when rising numbers of senescent cells seem to start causing problems.

Earlier this year, another team identified two drugs that might do the job. James Kirkland at the Mayo Clinic and his colleagues started by thinking about how senescent cells work. Unlike normal cells, they don't die, suggesting they possess some kind of survival mechanism. That makes them quite like cancer cells, says Kirkland, except they don't divide. By exploring known tricks used by cancer cells to defy destruction, his team has identified two cancer drugs that essentially force senescent cells to commit suicide.

Combined, the drugs have impressive effects in rodents. Mice given a single dose of each when they were the equivalent of 80 human years old had better heart function than untreated mice. In mice that had one leg irradiated – which would normally prematurely age it – there was less muscle wasting and, seven months after treatment, they performed better on a treadmill than untreated mice. The fact that a single dose can have such long-lasting effects is particularly promising, says Kirkland. “The drug only stays in the circulation for about 12 hours. A continued presence is not required to have an effect.”

Kirkland's team is now testing the drugs in monkeys. “The studies aren't published yet, but we have an indication that we're able to selectively kill senescent cells in monkeys as well,” he says. Human clinical trials are on the drawing board. The first candidates will be people with fatal or severe disorders linked to senescence, such as some lung and liver diseases. The drugs could also be injected into joints affected by osteoarthritis, where senescent cells are known to gather.

This approach might even be used to protect against age-related cancers, according to Campisi: although senescence stops cancers in some cases, in others senescent cells can actually promote the spread of tumours. Ultimately, Kirkland hopes his treatments might stave off frailty more generally, and keep older people living at home independently for longer. “A lot of 85-year-olds have five or six different conditions – diabetes, mild cognitive impairment, heart problems and osteoarthritis, say – and they're on 20 different drugs,” he says. “The question is: can we use these agents to alleviate multiple conditions with one drug?”

The reality is likely to be more complicated. Even if we could rid ourselves of these damaging cells simply by taking a pill every few years, there may be unintended

## Three reasons to die

Evolutionary theorists have three explanations for why ageing and death are inevitable

**WEAKENED SELECTION** This idea, first put forward in the 1950s, suggests natural selection works more strongly on the young. Potentially harmful mutations are filtered out more efficiently in early life, but in later life remain to cause ageing and death.

**MUTATING MUTATIONS** Perhaps some mutations are beneficial early in life, but detrimental later. These would accumulate via natural selection, helping to ensure survival to adulthood – but bring problems further on.

**“DISPOSABLE SOMA”** Organisms with only a limited amount of energy to invest prioritise reproduction over maintaining a healthy body, eventually running out of steam because they concentrate resources on the next generation.



PAUL LOWE/PANOS

## Can the Old Firm be made young again?

at University College London, wrote recently. "One should endure aging and bow out gracefully with stoicism and dignity in accordance with nature's wishes." Others argue from an ecological perspective, pointing out that the current human population of more than 7 billion is already unsustainable.

But Kirkland is not trying to extend life for its own sake. His goal, he says, is to stave off age-related diseases – if we live longer as a result, then that's an added benefit. Gems, at least, is persuaded by the preventive approach. "I'm really excited about the idea of targeting senescent cells as a treatment for ageing," he says. "There is nothing wrong with people living longer as a result of better health." Even Paul Ehrlich, a demographer at Stanford University in California who famously warned of the perils overpopulation poses to the environment, approves. "Programmes that let all people live the healthiest lives possible to the end are very desirable," he says, although they should be accompanied by incentives to lower birth rates and consumption.

That still leaves the intriguing questions of how much longer we might live, and what we will eventually die of. "It's hard to know," says Kirkland. Some clues come from exceptionally long-lived people. One such person was Hendrikje van Andel-Schipper, a Dutch woman who enjoyed good health and cognition almost to her death in 2005, aged 115. When researchers analysed samples of her blood last year, they found that the stem cell supply from which all blood cells originate was almost exhausted. A healthy young person might have 1500 such cells, which are used up over the years. She appeared to be down to her last two. All of our tissues rely on stem cells for regeneration, and those that undergo rapid renewal, such as blood, skin and guts, might be the first to wear out. "Without blood you'd become anaemic and die," says Henne Holstege at VU University Medical Center in Amsterdam, who led the research.

This suggests that even if we could regularly clear senescent cells from our bodies, there is a natural limit to lifespan. Perhaps that's no bad thing. On the other hand, it's quite exciting to think that our attempts to defy ageing could now go more than skin deep. "We're really starting to understand what's going on," says von Zglinicki. "We are getting to the stage where, for the first time, people will be able to realistically consider the prospect of anti-ageing solutions." ■

Jessica Hamzelou is a medical reporter at *New Scientist*

consequences that will only become apparent when such treatments are routine. And that's not all. "I don't think anyone believes that all of ageing is caused by senescent cells," says Campisi. Even enthusiasts for this line of work acknowledge that tackling ageing – or at least the debilitating diseases that accompany it – will require a multi-pronged approach. What form this should take is still far from clear. "We don't know much about the other factors," Campisi admits.

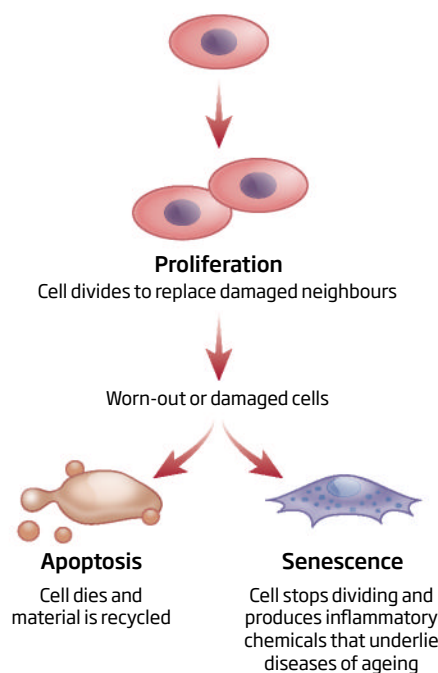
Everyday painkillers that target inflammation may offer some benefits. Restricting food intake also looks promising: drastically cutting down on calories extends the lifespans of worms and mice, although it doesn't seem to have the same effect in monkeys, and the jury is still out when it comes to humans.

Of course, simple lifestyle choices such as taking regular exercise and eating plenty of fruit and vegetables can help us age healthily. But despite knowing this, many of us fail to muster the will power required to change our ways. Still, Kirkland is optimistic. "I imagine there will be a combination of lifestyle interventions and drugs that will add substantially to the healthspan," he says.

If so, that will have wider implications. As well as improving health, the two drugs his team used seem to increase lifespan, at least in mice and monkeys. While this may sound enticing, there is debate among researchers as to whether helping people live longer is a worthy goal. "To refuse to accept aging is a sign of weakness of character, of egotism," David Gems, who researches ageing

## Road to senescence

Cells can only divide a certain number of times, then they either commit suicide or change character





# WORLDS OF PURE IMAGINATION

Astronomers are hunting exoplanets weirder than any spotted before. Adam Hadhazy introduces five alien worlds just over the horizon

**U**P UNTIL the mid-1990s, the only planets whose existence we knew about for certain were those in our own solar system. This narrow worldview was changed forever when the first exoplanets were found orbiting around pulsars – the burnt cinders of exploded, monster stars – swiftly followed by the discovery of gaseous titans in searing proximity to their suns. In the best traditions of exploration, these foreign planets were unlike anything we had previously imagined.

The variety of exoplanets bagged since then has only pushed the envelope further. Exoplanets, we have learned, are happy to bask in the simultaneous light of four suns, wander the galaxy as starless outcasts from their home solar systems or orbit whipper-snapper stars barely 1 million years old.

“What happened in our solar system hasn’t served us very well in predicting what we will find around other stars,” says Gregory Laughlin of the University of California, Santa Cruz. “We expected planets like we have here, but we’ve been continually surprised.”

With more exoplanets discovered in the last two years than at any time before, and the haul fast approaching 2000, astronomers wager there are plenty more surprises in store. Naive theories of what extrasolar worlds should be

like have been consistently outshone by the data, says Stefano Meschiari of the McDonald Observatory at the University of Texas at Austin. “We really didn’t know the extent of the diversity of exoplanets and configurations until we actually observed them.”

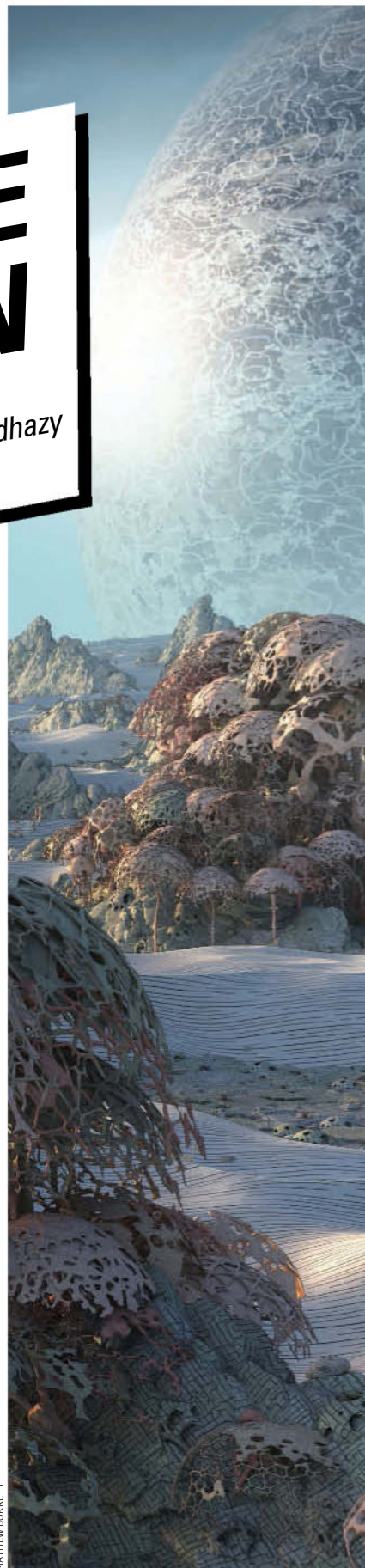
In an attempt to steal a march on nature, researchers are now busy imagining weird new types of exoplanet that might turn up in future. Far from being a parlour game for bored astronomers, understanding nature’s ability to produce planetary bodies will be crucial to learning how our solar system compares to its galactic counterparts. Many of these proposed exoplanets challenge our understanding of planet formation, and could play havoc with our admittedly arbitrary criteria for determining what constitutes a planet in the first place. Furthermore, exotic new planetary types should expand our inevitably Earth-centric ideas about where habitable planets might form, aiding in the search for alien life.

Here are five of the zaniest exoplanet types that could shake things up in the years to come.

---

Adam Hadhazy is a freelance writer based in New Jersey

MATTHEW BORRETT







## P1 | BINARY WORLDS

### PLANETARY DOUBLE ACTS ORBITING EACH OTHER IN A STATELY WALTZ

In our solar system, large planetary bodies are located far apart, orbited by moons of much smaller size. We think this familiar configuration emerges when bits of dust clump together in a protoplanetary disc encircling a young star, evolving into rocky hunks that Hoover up any material in their orbital paths. Moons can then be crafted from leftover detritus orbiting the planet, or else be hauled in during the chaotic pinballing of objects thought to happen in developing solar systems.

There is a third option, however. Widely accepted models suggest our own moon formed when a Mars-like body - dubbed Theia - smacked into the primordial Earth, gouging out material that coalesced into the satellite we know today. But if those two bodies had undergone a less spectacular collision, they could have ended up in a stable partnership. "If you changed the nature of the encounter that led to our moon, then you might have gotten the binary planet outcome," says David Stevenson of the California Institute of Technology in Pasadena.

Finding binary planets could therefore shed light on the rambunctious childhood years of fledgling solar systems. It would also prove that collisions of the kind that created our moon can be considered a viable route to planethood, and not just a way to form satellite hangers-on. "It would tell us that at least in some cases, planet formation proceeds by the close encounter of large, similar-sized bodies," says Stevenson. Fortunately for astronomers, binary exoplanets should cast distinctive double shadows as they cross and partially eclipse the shining faces of their stars - so-called transit signals readily detectable by NASA's Kepler telescope and other observatories designed to look for new worlds.

Undoubtedly the most intriguing configuration would be two Earthlike worlds locked in a binary orbit. Imagine if Earth had a habitable twin in our sky, and if life, or even a technological, space-faring civilisation, arose there in parallel to our own. "Would the planets be at war?" asks Stevenson. "Makes for great science fiction."



## P2 | PARTY PLANETS

### MULTIPLE WORLDS SHARING THE SAME ORBITAL PATH

Although the worlds in our solar system stick standoffishly to their own orbital lanes, they do tolerate company beyond their faithful moons. Asteroids dubbed Trojans, for instance, hang out at Lagrangian points, sweet spots where the gravitational force of a planet and its star balance out. These points move around the planet's orbit as it rotates, dragging their inhabitants along with them. Jupiter shepherds an army of Trojans around the sun, and Earth actually has a Trojan of its own, a tiny rock called 2010 TK7.

In theory, there is no reason why planet-sized objects couldn't also arrange themselves in such complex configurations. According to simulations by Gregory Laughlin of the University of California, Santa Cruz, and Stefano Meschiari of the University of Texas at Austin, multiple Earth-sized, habitable worlds might plausibly share a "party orbit", all at roughly similar distances from their host star. "It's not just two to tango," says Laughlin, "but three to four to five to six to tango."

Arrangements of this sort can be stable for billions of years – so long as there are no gravitationally perturbing worlds on either side of the crowded orbital band to disrupt its delicate choreography. "Planets with very similar orbital periods are totally possible," says Meschiari. What is less clear,

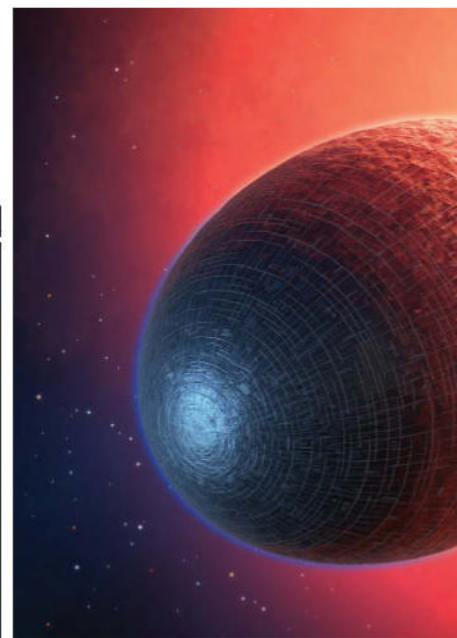
however, is how the bulk of a solar system's planet-making material would gel into a tight-knit batch of worlds. The hard part is not so much guaranteeing orbital stability, he says, "but whether nature actually allows the formation of these planets."

Researchers on the Kepler telescope got ahead of themselves in 2011, when they reported spotting the signature of two planets with the same orbital period. Further analysis showed one of the pair in fact had a significantly longer year, consigning it to a completely separate orbit. Although continued Kepler analyses are still our best bet to spot planets of this kind, future transit missions such as NASA's Transiting Exoplanet Survey Satellite (TESS) or ESA's Planetary Transits and Oscillations of Stars (PLATO) may get lucky.

The existence of co-orbital planets would upend the current doctrine that planets must keep their orbital backyards free of other large bodies – something that ousted Pluto from the full-planet club in 2006. These worlds could even cross-pollinate, thanks to meteorite impacts blasting out rocks harbouring hardy bits of genetic material. "The planets would share a genetic lineage," says Laughlin, with their unique environments driving biology down alternate tracks. "Evolution would proceed differently on those two worlds."

# "A PLANET IS LIKE A MELON - SQUEEZING IT CAN TEACH YOU ABOUT ITS INSIDES"

To test your own hand at designing a stable party planet system, go to [bit.ly/SuperPlanetCrash](http://bit.ly/SuperPlanetCrash)



## P3 | EGG WORLDS

### ROCKY PLANETS SQUEEZED INTO EXTREME SHAPES

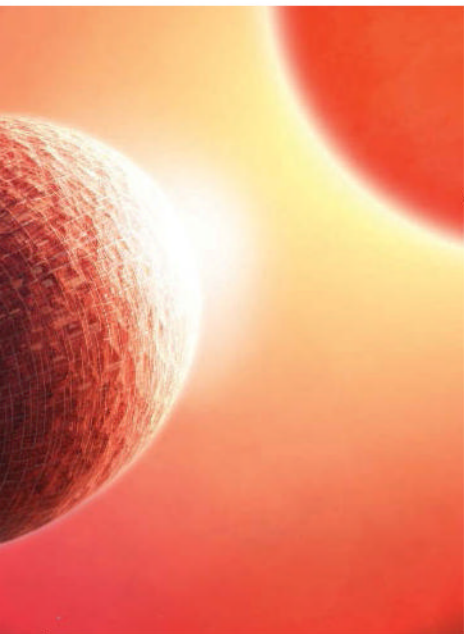
The gaseous giant WASP-12b orbits its star at such scorchingly close quarters that the strong stellar gravitational pull has warped it into a bulging oval. Prabal Saxena and his colleagues at George Mason University in Fairfax, Virginia, decided to explore how this tidal distortion might affect a rocky world such as Earth. They calculated that an exoplanet of this kind could stretch to be a fifth wider at its equator than from pole-to-pole before being torn asunder by its star (*Monthly Notices of the Royal Astronomical Society*, vol 446, p 4271).

The discovery of rugby ball-shaped worlds could be a boon for planetary science. "Aspherical exoplanets have the potential to tell us a lot about planetary interiors," says Saxena. The way a planet responds to a star's gravitational pressure would provide an entirely new way of learning about its composition. Squeezing



## P4 | CHTHONIAN PLANETS

### NAKED WORLDS WHOSE ATMOSPHERES HAVE BEEN BOILED AWAY



As solar systems evolve, the gravitational force planets exert on each other means they can slowly move inwards or outwards from their shared star. Called migration, this process helps explain the Milky Way's puzzling abundance of worlds the size of Neptune or Jupiter occupying star-hugging orbits. These massive exo-worlds must have formed further out, or else the star's radiation would have prevented their constituent materials from ever coalescing into a planet. Nudged towards a stellar furnace by migration, starlight withers away their atmospheres, eventually leaving nothing but their rocky cores. This exposure of the planet's hidden depths inspired the name chthonian, a reference to the deities of the Greek underworld.

There are broadly two types of scientifically valuable and potentially detectable chthonian planets. The first are habitable evaporated cores (HECs): cold, mini-Neptunes that migrate towards their stars' temperate, habitable zones. The extra stellar radiation they receive can blow off their atmospheres and even melt exposed surface layers of their rocky cores, which are rich in water ice. These planets could accordingly transform into ocean-covered worlds with life-friendly air, opening up a new avenue for the rise of alien life. "The surfaces of HECs used to be the gas-solid

interface deep in the planet's interior – a rather hellish place indeed," says astrobiologist Rodrigo Luger of the University of Washington in Seattle. "But once the gas evaporates away, you're left with a surface that's potentially habitable."

The other interesting type of chthonian planet starts out more like Jupiter, the iconic gas giant of our solar system whose origins are still shrouded in mystery. Studying the rocky core of such an exoplanetary gas giant stripped bare by its star would accordingly give scientists valuable insight into the sequence of planetary formation. "If you expose the core, then you see what happened first," says Laughlin.

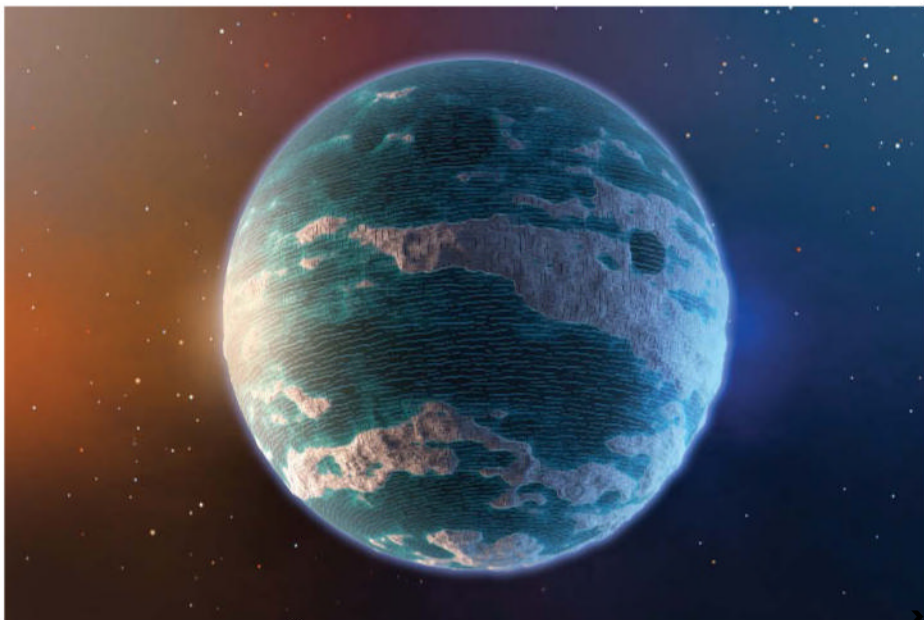
Catching the process of migration as it leads to atmosphere loss would be a valuable piece of evidence in favour of the chthonian planet theory. Intriguingly, Francesca Valsecchi of Northwestern University believes that the gaseous giant WASP-12b might be in just such an evolutionary phase: not only being squished by the gravity of its merciless star (see "Egg Worlds", left), but also having its atmosphere boiled away to nothing.

And as for the specific case of HECs, researchers believe their distinctively low densities suggests they migrated inwards from their solar system's distant outlands of ice and snow.

an object is a handy way to learn about its insides, says Laughlin: "Like at the grocery store, with a melon or a grapefruit."

The planetary equivalent of gauging a melon's ripeness would be determining whether a planet is mostly solid or gaseous. As rocky planets are more likely to be habitable, measuring a planet's flexibility would provide us with a way of determining its potential to harbour life, says Saxena. As a bonus, the atmospheres of ovoid worlds would experience different levels of gravity in different places, possibly making for intriguingly unpredictable climates.

Stay tuned, for these egg worlds might crop up in yet-to-be-processed data from NASA's Kepler telescope, or even be detected by space-based instruments such as TESS or huge ground-based telescopes scheduled to be built over the coming decade.





## Wacky worlds

Yet-to-be-discovered exoplanets could have shapes and orbits unlike anything seen in our solar system

### Binary worlds



Two planets of equal size, orbiting each other as they journey around a shared star

### Party planets



Multiple worlds occupying the same orbit, violating the conventional definition of a planet

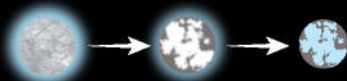
### Egg worlds



Rocky planets squeezed into highly eccentric shapes as a result of their star's strong gravitational pull

### Chthonian planets

Habitable Evaporated Cores (HECs)



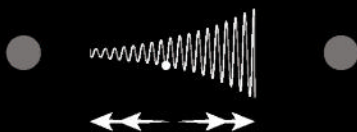
Gassy worlds born in a distant orbit that migrate towards their star. The sudden heat would evaporate their atmospheres, thawing their frozen cores into oceans capable of sustaining life

### Exposed Cores



Gaseous giants pulled towards their stars, where their thick atmospheres are boiled away to expose their hidden, rocky cores

### Corkscrew planets



Planets tracing a corkscrew orbit around the axis between two stars



## P5 | CORKSCREW PLANETS

### PRISONERS OF GRAVITY PING-PONGING BETWEEN TWO STARS

Even the craziest planets concocted by theorists still tend to trace conventionally near-circular orbits in a flat plane. Not so the corkscrew planet. Mind-bendingly, these worlds could exist in a sort of orbital limbo, spiralling about an axis between two stars in a binary system, pulled hither and thither by their competing gravities. The brainchild of theoretical physicist Eugene Oks of Auburn University in Alabama, these whirligig worlds represent a completely new type of stable, albeit speculative, planetary orbit.

Oks ran the numbers for a corkscrew planet pulled between the orange and red dwarf stars comprising Kepler-16, a binary system 200 light years from Earth. The planet would complete a manic loop-the-loop in its cone-shaped orbit in under an Earth week, straining our conventional definitions of a year (*Astrophysical Journal*, doi.org/4j6).

Any life that managed to survive on such a permalit planet, where seasons change in the span of days, would experience one of the weirdest night skies in the cosmos. Upon reaching one end of the corkscrew orbit and heading back

towards the other star, the closest sun would seem to suddenly reverse its direction in the sky. "I hope the would-be inhabitants of the planet would be accustomed to this," says Oks, "and would not get scared each time it happened."

It's not yet evident how stars could force a corkscrew world to settle into such an unusual orbit, though snagging a passing starless "lone wolf" planet seems like their best bet. And while the transit method could spot these planets (see "Binary Worlds", page 35), their true screwball nature would be harder to identify.

According to Oks's paper, a better way to find corkscrew planets is via gravitational waves, the ripples in space-time predicted by Einstein's general theory of relativity. Corkscrew planets should generate telltale additional gravitational waves that would stand out against the background signals produced by interacting stars. Direct detection of gravitational waves from any source has so far proved elusive, but with instruments getting ever more precise, Oks believes the distinctive behaviour of corkscrew planets could one day make them easily distinguishable. ■

# BUZZ WORDS

Language doesn't just communicate emotion, it also helps to shape it, says **Tiffany Watt Smith**

**O**VER the last couple of months, my husband and I have been trying to move house. Four times now we've fallen in love with a property, only to find ourselves mourning a future life we'd already come to adore when the sale fell through. And then I tell myself to snap out of it. Grief is what I'd feel if a member of my family died. Love is what I feel for my family, at a stretch my dog. Can a house really elicit the same emotions?

At these moments, I grope for the vocabulary to express these feelings in a more nuanced way. Is there no word for the grief of losing an imaginary life you've not even started? Is there a name for the love you can feel for a building and all that it promises? And perhaps more importantly, if there were, might I find the whole sorry business of moving house easier to deal with?

The idea that the way we speak about our feelings might influence how we feel them is hotly debated. Some evolutionary psychologists back the idea that all our feelings boil down to a handful of universal, basic emotions; gut responses which strike regardless of the culture we live in. Long before they learned to speak, our cave-dwelling ancestors would have felt the telltale physiological fear response – their hearts would hammer in their chest and their palms prickle with sweat if they watched a sabre-toothed tiger slope past. How else could they have been motivated to flee or fight? In this scheme of things, feelings came first, their names much later, as people learned to communicate. If so, disgust feels the same, whether you live in New York or Timbuktu.

But as a historian who studies how the meanings of our emotions have changed over the centuries, I struggle to accept this idea. Words aren't just labels. They also provide a scaffold for complex networks of ideas and concepts, spiritual beliefs, medical theories, social mores and expectations. While researching a new book on the subject, I was often struck by the diversity of this cultural baggage. For example, these days we might celebrate happiness, but in the 16th century some self-help authors encouraged people to feel sad, which they viewed as the more humble response to life's vicissitudes. Nowadays, sadness is often tinged with feelings of impatience or even shame. But declare yourself sad in the 16th century, and you might have had cause to feel a bit smug, too.

## No words, no worries

Look more closely at the world's languages, and the idea of universal emotions also takes a tumble. If disgust is a single primal emotion, why do Germans distinguish between two types of it – *ekel* (disgust that makes the gorge rise or stomach churn) and *abscheu* (usually translated as revulsion)? And that is nothing compared with the 15 kinds of fear that the Pintupi of Western Australia speak of. Some cultures identify feelings which have no obvious equivalent in English, like the Japanese *amae* or the Dutch *gezelligheid* (see definitions, overleaf). Equally, languages may lack words for emotions which English-speakers take for granted: the Machiguenga

people of Peru have no term which precisely captures the meaning of "worry", for instance. Could the fact that they don't have a word to convey this emotion mean they don't – or can't – feel it either?

Science is now being brought to bear on such questions. Brain imaging studies, for example, show a strong link between language and emotions: when the parts of the brain linked to emotion are aroused, so are those parts associated with semantics and language.

Some of these studies have shown what many of us know instinctively, that putting a name to a feeling can soothe us, bringing coherence to internal turbulence. But other cognitive scientists have gone further, suggesting that words play an even deeper role in constructing our emotional lives, not only helping us manage feelings, but actually bringing them into being in the first place.

Earlier this year, Kristen Lindquist at the University of North Carolina at Chapel Hill and her colleagues found that our ability to understand the meaning of words such as "happiness" or "anger" appears to have a measurable effect on whether we can recognise those emotions in others. In one experiment, they asked a group of volunteers to say the word "anger" out loud 30 times, to create a familiar effect known as "semantic satiation": words losing their meaning through repetition. Compared to a control group, these participants were slower and less accurate at recognising pictures of scowling faces as representing anger.

The team also carried out tests on people ➤



## AWUMBUK

There is an emptiness after visitors depart. The walls echo; the space which felt so cramped while they were around now seems weirdly large. And though there is often relief as well, we can be left feeling as if everything seems rather pointless.

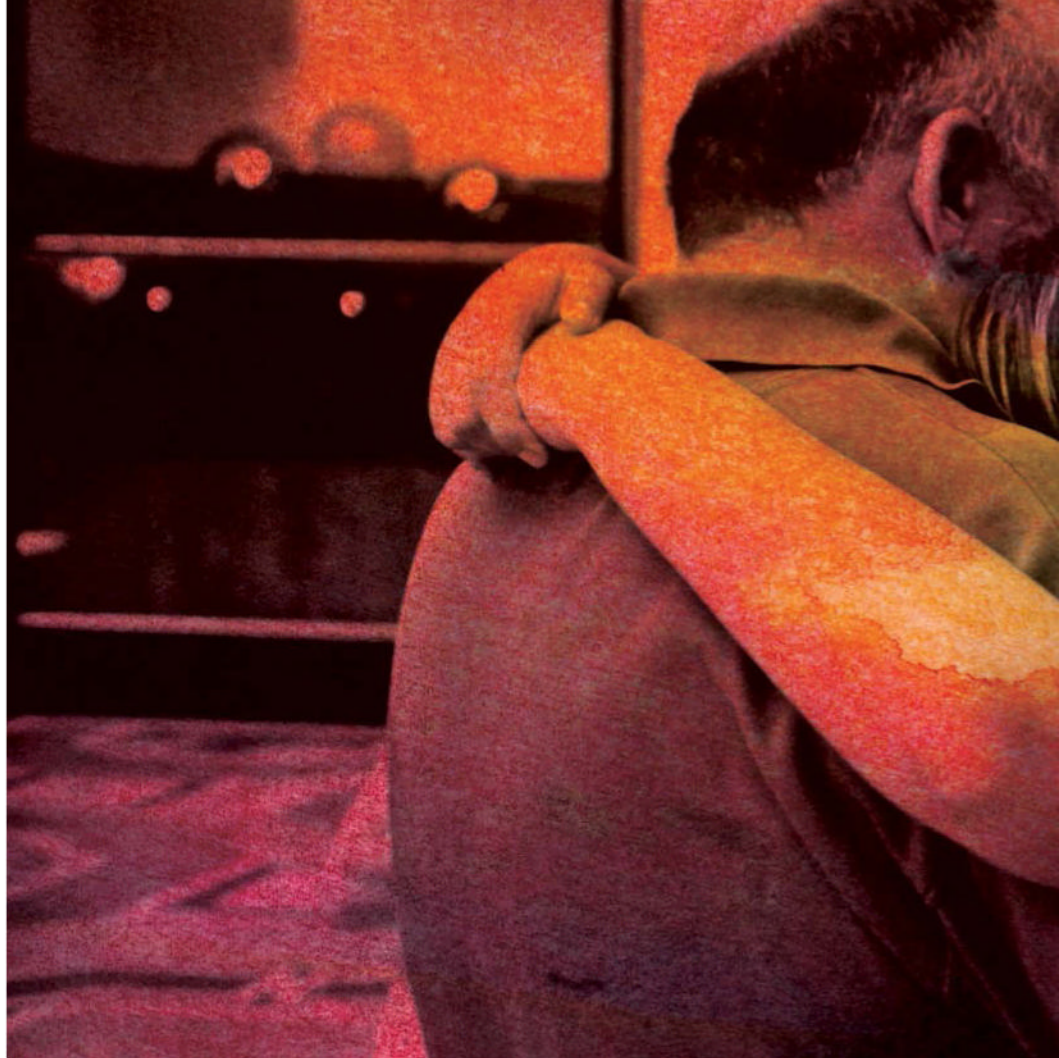
The Baining people who live in the mountains of Papua New Guinea are so familiar with this that they call it *awumbuk*. They believe that departing visitors shed a kind of heaviness into the air, so as to travel lightly (see main story). This oppressive mist lingers for three days, creating a feeling of distraction and inertia and interfering with the hosts' ability to tend to their home and crops. To dispel it, the family fills a bowl with water and leaves it overnight to absorb the festering air. The next day, they rise very early and ceremonially fling the water into the trees, whereupon normal life resumes.

## GRENG JAI

In Thailand, *geng jai* is the feeling of being reluctant to accept another's offer of help because of the bother it would cause them.

## IKTSUARPOK

When visitors are due to arrive, a fidgety feeling sprouts up. We might keep glancing out of the window or pause mid-sentence, thinking we've heard the sound of a car. Among the Inuit, this antsy anticipation, causing them to scan the frozen Arctic plains for approaching sledges, is called *iktsuarpok*. Might the restless checking of our phones, waiting for an expected response to a text or comment on a status update, be a type of *iktsuarpok*? Constantly refreshing the screen to see if a hoped-for email has arrived can feel like one of the most distracting aspects of contemporary life. Perhaps it's not the technology, however, as much as our desire for human contact in an isolating world, which is to blame. (See also *awumbuk*).

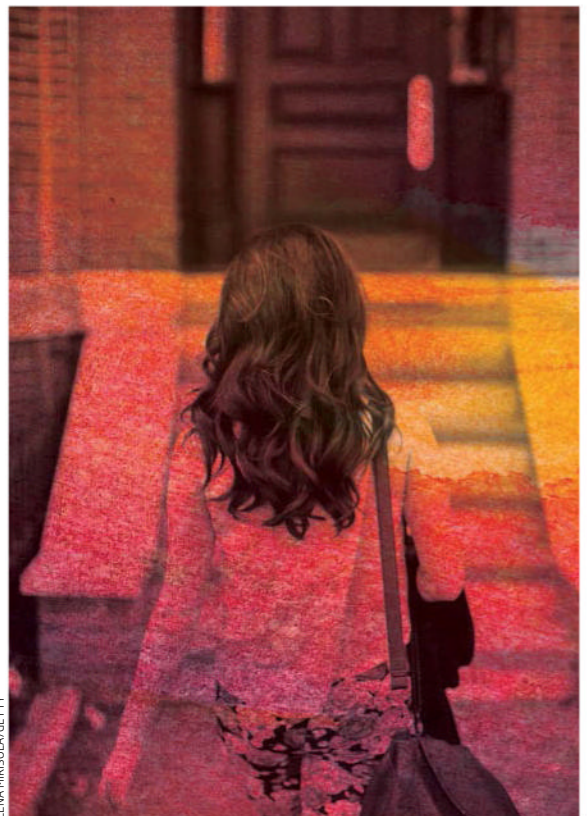


## AMAE

Most of us have on some occasion felt the urge to crumple into the arms of a loved one to be coddled and comforted. It's important and reviving, this sensation of temporary surrender in perfect safety. The concept is not easily captured in English, but Japanese people know it as *amae*, the feeling of being able to depend on another's love and help with no obligation to be grateful in return. It helps relationships to flourish and is an emblem of the deepest trust.

In the 1970s, Western anthropologists became very excited about *amae*, claiming that it was evidence that even our most intimate emotions are shaped by the societies in which we live. They argued that Japan's traditional collectivist culture had allowed *amae* to flourish.

So one wonders why those of us who grew up speaking English often fumble when trying to articulate a similar experience. Perhaps this lacunae in English speaks volumes about how hard it can be to accept other people's support.



LENA MIRISOLA/GETTY



GABRIELE LOPEZ / MILLENNIUM IMAGES, UK

“Without the right words, we might not be able to register emotions in the faces of other people”

culture will always influence what we see.

Lindquist’s team also thinks that the same processes may be at work in recognising our own feelings. Learn a word for an emotion, and it may act as a lightning rod, attracting all kinds of inchoate sensations and vague inklings. Once we learn to link that word to a particular network of sensations, our brains find it easier to seek out experiences which are consistent with it and filter out those which aren’t.

Consider *awumbuk*, the inertia felt when a house guest leaves, a common emotion among the Baining of Papua New Guinea. Baining people believe *awumbuk* is caused by a heaviness in the atmosphere left by departing visitors, and they leave a bowl of water out overnight to absorb it, flinging the contents away the next morning.

If a guest leaves my house, I might feel sorry to see them go. But if I were a Baining, I might expect to feel *awumbuk*, and then all kinds of other expectations will come into play: that I ought to feel fuzzy-headed; that when I throw the water away, these feelings will disappear. These beliefs will bring some sensations to the forefront of my mind to create a coherent experience, and so will tangibly influence my emotions.

It works both ways. There are other feelings that go unnamed and so stay unnoticed. As far as the conscious mind is concerned, they are unfelt. It might even make sense to say that when a language lacks the name for an emotion, the feeling can fade into the background, unformed, even lost.

If true, this finding has important therapeutic consequences. Last year Jordi Quoidbach at Pompeu Fabra University in Barcelona, Spain, and his colleagues found that “emodiversity” – experiencing an abundance and wide range of emotions – is strongly correlated with long-term emotional and physical health.

So if you want to bring some variety into your emotional life, try familiarising yourself with *geng jai*, *iktsuarpok*, “homefulness” or *amae*, and you might just notice yourself experiencing new feelings as a result in your daily life too. Just beware of basorexia – the sudden urge to kiss someone. ■

Tiffany Watt Smith is a researcher at the Queen Mary University of London Centre for the History of Emotions. Her latest book, *The Book of Human Emotions*, is published by Profile Books in association with the Wellcome Collection

## HOMEFULNESS

In 1841, the poet John Clare escaped from High Beech asylum to get home to his beloved. For three and a half days he walked with broken shoes, sleeping in porches and eating grass from the roadside. In a letter he wrote describing the journey, he tells of the feeling when, exhausted and foot-sore, he reached a crossroad pointing to home and was suddenly restored: “I felt myself in home’s way”.

The writer Iain Sinclair, who retraced Clare’s journey, used the little-known word “homefulness” to describe Clare’s feeling at this point. He became full with the feeling of home.

The feeling of “homefulness” surges up at the end of a long journey, but after less-arduous travels too: it’s there when we step off the plane after a holiday or turn into our road with shopping bags bulging. It spreads through us with its combination of relief, belonging and the satisfaction of a long journey’s end.

## EXPRESS YOURSELF!

Ever had a feeling you just can’t name? Tell us your word for it on Twitter, Facebook and Instagram using #thatfeeling

diagnosed with semantic dementia, a neurodegenerative disorder which destroys the ability to recall the meaning of words. Both patients and a control group were asked to sort photographs representing six emotional states into separate piles. The healthy participants sorted the photographs into six groups. Those with semantic dementia often created only three piles: one for unpleasant feelings (anger, sadness, disgust, fear), one pleasant (happiness) and one neutral.

These tests suggest that telling the difference between an angry face and one grimacing in disgust is not as straightforward as we might think. Without the words we use to understand emotions, we might not even be able to register the faces as expressing different feelings at all. This suggests to me that when we identify even apparently basic emotions in other people, our language and



# Are we worthy?

A new, better world may not be possible, says **Bruce Sterling**

*How to Thrive in the Next Economy: Designing tomorrow's world today* by John Thackara, Thames & Hudson, £18.95



BEFORE 2008, “next economy” books were a dime a dozen. They’ve been thin on the ground lately, but John Thackara has just published one

of a decidedly different bent.

An incessant traveller, thoughtful listener and the former “symposiarch” of the legendary Doors of Perception events of the 1990s, Thackara is a beloved figure in sustainable-design circles. A guru of labs and think tanks worldwide, he is painfully aware of the crises facing the world in 2015.

Most new-economics gurus would crassly motivate their readers to get rich quick online. By contrast, in *How to Thrive in the Next Economy*, Thackara tackles our planet’s most basic survival topics – preserving soil from erosion, supplying clean water and keeping people sheltered, fed, healthy and mobile. There’s a light dusting of digital here, but for the most part, the author sternly confronts every major environmental issue that has worsened in his lifetime.

As Earth’s situation gets more perilous, we don’t wise up and reform, we just embrace our myths ever more tightly. So Thackara sees little promise in political solutions. Likewise, private enterprise cannot do

much because it is laced into a fatal straitjacket of optimising return on investment, even if that means levelling forests and blackening skies.

Thackara’s inconvenient mathematics expose our planet’s decline, but despite his ill-concealed dread he stoutly refuses to “head for the hills with a truckload of guns and peanut butter”. That prospect obviously tempts him, but a guru should not become a doomsayer and abandon the world. Somehow, humans must “thrive”, although by Thackara’s reckoning, thrive means surviving with about 5 per cent of the energy and resources most Westerners avidly consume.

It’s hard to talk rich, heavily armed people into sacrificing 95 per cent of everything they have grabbed, but Thackara thinks that it is necessary,

physically possible and a praiseworthy moral effort.

His book is full of examples of people who already manage such a pared-down life: Lagos kiosk traders, Indian jugaad tinkerers, Central American cooperative farmers, Danish bike sharers and the like. These marginal, sociable groups seem obscure and humble, mostly because they tend to avoid

**“As Earth’s situation gets more perilous, we don’t reform, we just embrace our myths more tightly”**

the focused, malignant attention of governments and markets.

So, argues Thackara, if these ingenious refuseniks haven’t been methodically crushed by our dominant, ill-conceived legal and financial systems, others might indeed thrive, or at least do better

by copying their thrifty ways.

In my own wanderings, I have also encountered under-the-radar activist groups, such as Brazilian Gambiologia tech-art hackers and Serbian pirate street-marketeers. So I share Thackara’s awareness that “material poverty” is a relative thing. If you’ve got a few thousand calories along with a dry spot to sleep, a backpacker’s simplicity is not as bad as bankers would have you believe.

In fact, I’m quite a fan of Thackara’s bonhomie, ingenuity and can-do designer abilities; if the two of us were marooned on a desert island, I bet we would have a rather jolly time of it. However, as Henry David Thoreau found out beside Walden Pond, the worst problem with noble simplicity isn’t the lack of cash, status and shiny appliances. It’s the monotony.



**Soil erosion is one of Earth’s most pressing problems**

Even if this “thriving” life is doable, where’s the aspiration, the ambition, the raw possibility? They’ve all been trimmed back by 95 per cent, because bold swagger and transformational technology will no longer do on the wounded surface of our fragile planet.

Anyone reading Thackara’s book will certainly get a much improved idea about what genuine 21st-century mass poverty will look like. It will be crowded, chatty and socially networked, yet still very poor, and with no ladders upward.

It will also be very threatened, because any angry gang of mountain bandits with Toyota trucks and machine guns could easily conquer a peaceable eco-village co-op.

As for states and markets, their power and malignity isn’t withering away, it’s intensifying. The radical niche and attic life Thackara is describing here is being crushed by most powers that be rather than ignored or encouraged, much less allowed to sweep over us in a vast wave of profound transformation.

Frankly I wonder whether humans deserve a position in a thriving economy. Given our résumé as a species, who would hire us? Any wise, sceptical alien would notice that plankton, grass, ants and termites all do a much better job at saving Earth than humans. If we raucous anthropoids really want to save a planet, we should probably try to upgrade Mars or Venus, low-rent planets that we weren’t born on.

If we could sit still in our rooms like coral polyps, we wouldn’t be killing the coral reefs. But we are killing them, and troubled spirits like ourselves will never rest content with what we ought or ought not to do. This book is a thoughtful plan for a better and very different world, but it’s one that we don’t deserve, can’t have and won’t get. ■

Bruce Sterling is a sci-fi writer variously based in Austin, Turin and Belgrade



## Lessons to learn

Reading the past reveals how not to treat refugees, finds **Linda Geddes**

*Contagious Communities: Medicine, migration, and the NHS in post war Britain* by Roberta Bivins, Oxford University Press, £35



MIGRANTS are the “physical rejects” of other countries; Britain harbours “a pool of ill health... which is constantly being replenished”.

These quotes could easily have come from one of the UK’s right-wing newspapers today. In fact, they come from a 1958 editorial in the *Birmingham Post* in response to the annual meeting of the British Medical Association, where fears of migrants casting the UK back into the dark ages of tuberculosis (TB) were rife.

Ten years earlier, in July 1948, the UK’s National Health Service launched. And the month before that, the Empire Windrush, carrying 492 migrants from Britain’s West Indian colonies, docked at Tilbury, heralding the start of mass migration to the UK.

In *Contagious Communities*, Roberta Bivins, a medical historian at the University of

Warwick, UK, argues that both events transformed what it meant to be British. Using case studies of diseases such as TB, rickets and sickle-cell anaemia, she explores how medical and political responses to the migrants were tinged by a vision of national modernity shaped by the NHS.

The UK saw itself as a country of fairness and prosperity, at the cutting edge of medicine. But the arrival of large numbers of people from overseas challenged this narrative. Using press cuttings, parliamentary records, reports in *The Lancet* and the *British Medical Journal*, and irate letters to the

**“Raising concerns about the impact of migration on health was an acceptable way to vent deeper fears”**

Ministry of Health, Bivins shows how perceptions of disease in migrant communities were often at odds with real data. Raising concerns about the impact of migration on health was an acceptable way to vent deeper fears and prejudices, it seems.

I was fascinated by the parallels with modern debates about

immigration and the untenable pressure on the NHS. Take TB. By the mid-20th century, the UK was proud to have largely confined it to history. But stubborn pockets among the poorest were overlooked, and rather than tackle that poverty, politicians and the media scapegoated immigrants, calling for greater medical surveillance at ports of entry.

Impressively, ministry civil servants stood firm. There was little evidence for TB being imported by immigrants – if anything, they were less likely to have faced the disease. Ironically, this made them more susceptible to it in their city slum homes.

But pressure on the ministry was becoming irresistible, and the genuine importation of another “historic” disease finally broke its back. An outbreak of smallpox in Bradford in 1962, transmitted by a girl from Pakistan, marked the time when “all the spaces in which migrants and residents... encountered each other were painfully and enduringly medicalised,” writes Bivins. The ministry tried to impose extra health checks on immigrants: to be Pakistani was to be identified with a disease eradicated from the “civilised” world. This has had lasting repercussions.

Here, Bivins’ writing is at its best: from accounts of the family to media reports and diplomatic correspondence with Pakistani officials, her attention to detail brings it all to life. Elsewhere, that detail is her undoing, and I often struggled to grasp her point.

Perhaps because the issues are so complex, there cannot be one simple message. But there is a general lesson here: when it comes to immigrant health, inflammatory headlines do not necessarily reflect the facts. In the current climate, policymakers would do well to ponder the past as they plan our shared future. ■

Linda Geddes is a consultant for *New Scientist*



# Feeling the chemistry

It's the age-old choice: after your studies, do you go into academia or industry? **Suzanne Elvidge** finds out what life after a chemical engineering degree has to offer

**I**T MIGHT seem like a big step from wanting to write children's fiction to heading up chemical engineering at one of the US's top universities, but for Professor Paula Hammond, department head and David H. Koch professor at MIT, it was a change of direction inspired by a high school chemistry teacher.

Chemical engineering is a multidisciplinary area, combining chemistry, engineering, physics, applied math and biology and this is its appeal for many students. Postgraduate studies open doors to academia and industry, from alternative energy and sustainable technologies through biopharmaceuticals and all kinds of manufacturing.

## Finding a postgraduate course

Choosing a school is a very personal decision, as different students will thrive in different environments. For Hammond, visiting MIT was about finding a community of people who, like her, were excited about science and engineering. For others, it's about the emphasis



of the course or the experience of the tutors. Location is also a significant factor, as Ethan Smith, a chemical engineering graduate from North Carolina State University (NCSU) in Raleigh who moved to Virginia Tech University in Blacksburg to begin a PhD, explains.

"If you are interested in a program, consider that you'll be there for possibly five or more years," he says. "Your life will move there. The reputation of the university is great to consider, but if you aren't going to be happy living there, you may want to evaluate that choice."

## "The most important thing is finding a school that is a good fit for you"

Lisa Bullard, a chemical engineering professor at NCSU, adds, "Overall, the most important thing is finding a school that is a good fit for you, and one in which you feel at home when you visit."

## Industry or academia?

Back in the 1950s, courses prepared students to work in the petroleum, chemical and plastics industries. However, chemical engineering is changing fast and now encompasses many different fields. These include biochemical, biomedical and biomolecular engineering, environmental science, technology, energy generation, sustainable materials, software engineering, nanotechnology, food and processing, and even medicine and law.

## CASE STUDY A CAREER IN CHEMICALS



PAULA HAMMOND is a case in point for the multidisciplinary nature of chemical engineering.

Hammond started her academic career at MIT, gaining her BS in chemical engineering in 1984. She had a summer

internship at Dow Chemical Company and worked for two years as a process engineer at Motorola, where she enjoyed the problem-solving aspects. After gaining her MS from Georgia Tech in 1988, where she was also involved with the Georgia Tech Research Institute, an R&D organization, she realized that her real passion was being part of a university setting and working with students, as well as having the opportunity to carry out research with longer-term goals.

"I wanted to be able to pair science with solutions and be

There are a number of areas where the role of chemical engineers is likely to grow, including clean energy generation, the development and manufacturing of novel materials, and the increase in precision and targeted medicine. For some current students, the ambition to work in industry is clear.

"My plan is to find a job that makes use of my chemical engineering background," says Christianna Carter, a chemical engineering undergraduate student at NCSU. "I'm interested in the business development and marketing field, finding new markets or new applications for company products."

For other students, the ultimate attraction is to a research and teaching career.

"An academic career seems to best fit my current interests," says Michael Burroughs, who is studying for a PhD in chemical engineering at the University of California, Santa Barbara. "As a professor, I could continue to work at the forefront of scientific research while mentoring and inspiring young scientists to reach their fullest potential."

However, it's important to remember that academic research and industrial work are both very different than being a student, and so potential industrialists and academics need to keep an open mind and learn about the different options.

"Take opportunities to participate in research at school as well as industrial internships or co-ops," says Susan Choi of the chemistry faculty at Camden County College in Blackwood, New Jersey. "Exposure to professionals and the type of work they do

able to follow the research all the way through to the end," Hammond explains.

She applied to MIT and was accepted to study a PhD in polymer science. Over the next two decades, she rose through the department to her current role.

In July 2015, Hammond, the David H. Koch professor in engineering at MIT, became the first woman and first person of color to be appointed head of MIT's chemical engineering department. Her research focus is on biomaterials and drug delivery.

can help students to discern their passion. Graduate school will provide an opportunity to see first-hand how professors run their research programs. Talk with professors or a mentor about how they got started and the rewards and challenges of academic research."

Industry experience provides the opportunity to work on real-world problems, which can change perspectives for those who choose to move into research and teaching.

## "Talk with professors about the rewards and challenges of research"

"My PhD work was in the area of process design and optimization," says Bullard. "I was interested in academia but felt that I should really go apply my specialization and gain experience before trying to teach this topic to others. By working in industry for nine years, I gained hands-on experience, which has been invaluable. It also helps me do a better job of advising students about industrial careers and graduate school options."

## Making the right choice

Deciding which path to choose can seem like a daunting one, but it's not a once-and-for-all decision; many faculty members have had a foot in both academia and industry. Choi went straight into industry after graduate school, for example.

"It provided an opportunity to do high-level research without having to spend large amounts of time on grant proposals to support my work," she says. "I was also attracted by the wide range of career opportunities that were available beyond working in the laboratory."

Careers are much more fluid these days, and it is possible to combine teaching and industry, as Frances Arnold, Dick and Barbara Dickinson professor of chemical engineering, bioengineering and biochemistry, and director of the Donna and Benjamin M. Rosen Bioengineering Center at Caltech, explains. "I run an active research program and teach. But I also start and advise companies that translate the basic technology into products," she says. "Both academia and industry are wonderful. Industry might have more constraints [such as making a profit], but I see fantastic opportunities in both arenas. Go with your heart." ■

Suzanne Elvidge is a freelance writer in biopharma and the life sciences



## Faculty opportunities

### Harvard University Faculty of Arts and Sciences, Cambridge, MA Department of Chemistry & Chemical Biology TENURE-TRACK PROFESSOR



**Position Description:** The Department of Chemistry & Chemical Biology seeks to appoint a tenure-track assistant professor in the open field of chemistry and chemical biology. The appointment is expected to begin on July 1, 2016. The tenure-track professor will be responsible for teaching at the undergraduate and graduate levels.

**Basic Qualifications:** Doctorate or terminal degree in chemistry or related discipline required by the time the appointment begins.

**Additional Qualifications:** Demonstrated excellence in teaching is desired.

**Special Instructions:** Please submit the following materials through the ARIeS portal (<http://academicpositions.harvard.edu/postings/6320>). Applications must be submitted no later than October 15, 2015.

1. Cover letter
2. Curriculum Vitae
3. Teaching statement (describing teaching approach and philosophy)
4. Outline of future research plans
5. Names and contact information of 3-5 references (three letters of recommendation are required, and the application is complete only when all three letters have been submitted)
6. List of publications

Harvard is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability status, protected veteran status, or any other characteristic protected by law.

**Contact Information:** Helen Schwickrath, Search Administrator, Department of Chemistry & Chemical Biology, Faculty of Arts and Sciences, Harvard University, 12 Oxford St., Cambridge, MA 02138. Phone: (617) 496-8190.

**Contact Email:** [Helen@chemistry.harvard.edu](mailto:Helen@chemistry.harvard.edu)



### Faculty Positions in Biochemistry and Molecular Biophysics

The Department of Biochemistry and Molecular Biophysics at Washington University School of Medicine invites applications for several tenured/tenure-track faculty positions at the level of Assistant/Associate/Full Professor. Successful candidates will have established a strong record of research. Applicants seeking tenured positions must have a strong record of external funding.

Outstanding individuals working in any area of biochemistry and molecular biophysics are encouraged to apply. The candidate's research should be aimed at addressing fundamental questions related to molecular mechanisms of biological or biomedical relevance. Current research in the department spans a wide range of topics including computational biology, membrane proteins, molecular motors, nucleic acid / protein interactions, protein structure, enzymology and signal transduction. Additional information about the department is available at <http://www.biochem.wustl.edu>. Washington University has a highly interactive research environment with vigorous interdisciplinary graduate and medical scientist training programs.

Applicants should email their curriculum vitae, brief description of their research interests, and contact information of three individuals to the Search Committee at [bmbsearch@biochem.wustl.edu](mailto:bmbsearch@biochem.wustl.edu). The committee will request letters from these individuals as necessary.

Completed applications will be reviewed on a rolling basis, starting immediately. For full consideration, applications should be received by December 1, 2015.

*EOE/Minorities/Vets/Disabilities. The School of Medicine at Washington University is committed to finding solutions to global health problems, including ones that affect minority and disadvantaged populations.*

## Annual Biomedical Research Conference for Minority Students (ABRCMS)

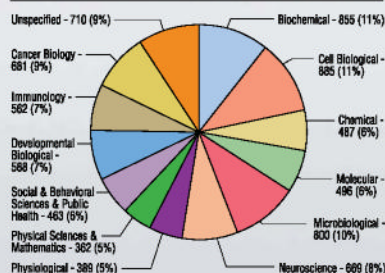
Washington State Convention Center • Seattle, WA • November 11-14, 2015



**ABRCMS** advances undergraduates and postbaccalaureates from underrepresented populations, including those with disabilities, in science, technology, engineering and mathematics (STEM) along the path toward graduate-level training. The conference features 1,700 poster and oral presentations, scientific sessions, professional development and networking sessions, and approximately 325 exhibit booths showcasing summer research and graduate school opportunities.

*"Attending and winning in my category was one of the best experiences in my scientific life. Coming from my background, I doubted myself in the past. I now feel confident because when I presented my poster I left like I belonged. This conference really made me believe that I can pursue a career in science."* STUDENT

### 2014 Distribution of Scientific Disciplines



### Important Deadlines

**Abstract Submission:** ..... September 11, 2015

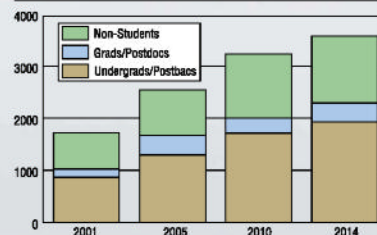
**Travel Award Application:** ..... September 11, 2015

**Judges' Travel Subsidy Application:** ..... September 25, 2015

**Discount Registration:** ..... October 19, 2015

For more information, please visit: [www.abrcms.org](http://www.abrcms.org).

### ABRCMS Registration



[facebook.com/abrcms](https://www.facebook.com/abrcms)

[twitter.com/abrcms](https://twitter.com/abrcms)

[abrcms@asmusa.org](mailto:abrcms@asmusa.org)

Managed by:





## KANSAS STATE UNIVERSITY



### Assistant/Associate Professor Physics Education Research Kansas State University

The Department of Physics at Kansas State University seeks a faculty member to join its physics education research (PER) group. Experience with research on the teaching and learning of physics that complement and/or expands the existing PER efforts at KSU will be considered favorably. The successful candidate will be appointed at a rank of tenure-track Assistant or Associate Professor in the Physics Department. Candidates must present credentials which will justify appointment at one of these levels. Minimum requirements include a Ph.D. in physics education research or equivalent and research experience beyond the doctorate.

The Department has an outstanding physics education research program (KSUPER), which was founded in 1972. At present KSUPER includes two faculty members. A detailed description of research activities, post-docs and graduate students in KSUPER can be found at <http://www.phys.ksu.edu/ksuper>. For further information contact Eleanor Sayre ([esayre@phys.ksu.edu](mailto:esayre@phys.ksu.edu)) or Dean Zollman ([dzollman@phys.ksu.edu](mailto:dzollman@phys.ksu.edu)).

The successful candidate will also demonstrate a strong commitment to teaching and mentoring of students and to serving a diverse population. He/she will be expected to obtain external funding for research activities, collaborate with other faculty in physics and other academic departments and build a national and international reputation in PER.

Applications should be sent, to PER Search Committee, 116 Cardwell Hall, Kansas State University, Manhattan, KS 66506-2601 or to [persearch@phys.ksu.edu](mailto:persearch@phys.ksu.edu). Applications should include a cover letter that addresses qualifications for the position, a curriculum vita, and statements of research and teaching interests. The applicant should arrange to have three letters of reference sent to the address above.

**Screening of applicants will begin on December 1, 2015, and continue until the position is filled.**

*Kansas State University is an Equal Opportunity Employer of individuals with disabilities and protected veterans and actively seeks diversity among its employees. Background checks required.*

## KANSAS STATE UNIVERSITY



### ASSISTANT/ASSOCIATE PROFESSOR SOFT MATTER EXPERIMENT CONDENSED MATTER GROUP DEPARTMENT OF PHYSICS

The Department of Physics at Kansas State University seeks an experimental physicist with research interests in soft condensed matter physics. Areas of interest include nanoparticle assembly, biological problems at the cellular and molecular levels, emergent phenomena, macromolecules, structured fluids, colloids and aerosols, and light scattering and its application to these systems. Such a scientist might engage in experimental research at the molecular or continuum levels of these physical or biological systems. Cross disciplinary research plans that overlap with ongoing AMO projects in the department (strong field laser-matter interactions, plasmonics, ultrafast charge transport) will be reviewed with interest, but are not required. The successful candidate will be appointed at the rank of tenure-track Assistant or Associate Professor in the Physics Department. Candidates must have a PhD in physics or a closely related field. To be considered for the Associate level position candidates must present credentials which will justify appointment at that level. The successful candidate should also demonstrate a strong commitment to teaching and mentoring of students and to serving a diverse population.

The Department has outstanding experimental and theoretical Condensed Matter physics programs involving seven faculty members most of whom are involved in research related to soft matter physics. Faculty research interests include synthesis and self-assembly of nanoparticles, surface structure and surface interactions of nano/bio components, light scattering, metallic and conducting polymer nanowire fabrication and applications, cellular adhesion and migration, aggregation phenomena for both proteins and particles, and nanostructured magnetic systems. The soft matter group has strong ties and collaborations with faculty in Chemistry, Biology, Biochemistry, Mechanical Engineering, Chemical Engineering, Grain Science, and the Terry C. Johnson Center for Basic Cancer Research. A description of research in the physics department can be found at:

<http://www.phys.ksu.edu/research/condensed-matter.html>

Applications should be sent to The Condensed Matter Search Committee, 116 Cardwell Hall, Kansas State University, Manhattan, KS 66506-2601 or to [softmattersearch@phys.ksu.edu](mailto:softmattersearch@phys.ksu.edu). In addition to a curriculum vita, applications should include statements of research and teaching interests. Candidates should arrange for three (3) letters of reference to be sent as well.

*Kansas State University is an equal opportunity employer and actively seeks diversity among its employees. Background check required.*



## RADCLIFFE INSTITUTE FOR ADVANCED STUDY HARVARD UNIVERSITY

### Academic Fellowships

The Radcliffe Institute Fellowship Program at Harvard University welcomes fellowship applications in natural sciences and mathematics. The Radcliffe Institute for Advanced Study provides scientists the time and space to pursue their career's best work. At Radcliffe you will have the opportunity to challenge yourself. Meet and explore the work of colleagues in other fields. Take advantage of Harvard's many resources, including the extensive library system. Radcliffe Institute Fellowship Program invites applications from people of all genders, and from all countries. We seek to build a diverse fellowship program.

Scientists in any field who have a doctorate in the area of the proposed project (by December 2014) and at least two published articles or monographs are eligible to apply for a Radcliffe Institute fellowship. The stipend amount of \$75,000 is meant to complement sabbatical leave salaries of faculty members. Residence in the Boston area and participation in the Institute community are required during the fellowship year.

**Applications for 2016-2017 are due by October 15, 2015.**

For more information, please visit [www.radcliffe.harvard.edu](http://www.radcliffe.harvard.edu) or email [sciencefellowships@radcliffe.harvard.edu](mailto:sciencefellowships@radcliffe.harvard.edu).

## Berkeley

Department of Chemistry  
UNIVERSITY OF CALIFORNIA Faculty Position in Chemistry

The Department of Chemistry at the University of California, Berkeley invites applications for one tenured faculty position at the associate/full professor level with an expected start date of July 1, 2016 in the broadly defined field of experimental physical chemistry. The basic qualification for this position is a Ph.D. or equivalent degree in Chemistry or a related field at the time of application.

All applicants should submit their most recently updated curriculum vitae, a three to five-page statement of future research plans and a statement of teaching. Additionally, please provide contact information for three to five references. We will only contact your referees if you are a finalist for the position, and we will seek your permission before doing so. A cover letter is optional. Applications should be submitted electronically through our web-based system at: <https://aprecruit.berkeley.edu/apply/JPF00804>.

All recommendation letters will be treated as confidential per University of California policy and California state law. Please refer potential referees, including when letters are provided via a third party (i.e., dossier service or career center), to the UC statement on confidentiality (<http://apo.berkeley.edu/evalltr.html>) prior to submitting their letters.

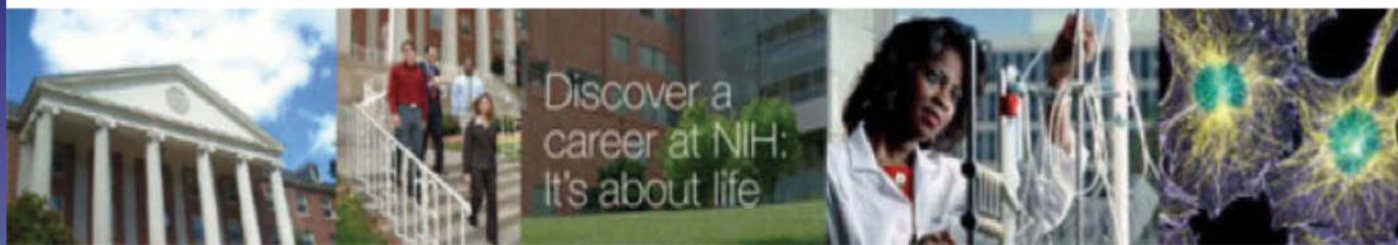
The deadline to apply for this position is November 2, 2015. Please direct questions to Lauren Nakashima ([lnakashima@berkeley.edu](mailto:lnakashima@berkeley.edu)).

The University of California is an Equal Opportunity/Affirmative Action Employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability, age or protected veteran status. For the complete University of California nondiscrimination and affirmative action policy see: <http://policy.ucop.edu/doc/4000376/NondiscrimAffirmAct>.

UC Berkeley is committed to diversity in all aspects of our mission and to addressing the family needs of faculty, including dual career couples and single parents. The Department of Chemistry is interested in candidates who will contribute to diversity and equal opportunity in higher education through their teaching, research, and service.



# Director, Division of Extramural Activities National Eye Institute



The National Eye Institute (NEI), a component of the National Institutes of Health (NIH) and the Department of Health and Human Services (DHHS), conducts and supports research, training, health information dissemination, and other programs with respect to blinding eye diseases, visual disorders, mechanisms of visual function, preservation of sight, and the special health problems and requirements of the blind.

Are you an experienced Scientific Administrator in search of an exciting career opportunity? We may be the right place for you. The NEI at the NIH is seeking an exceptional Scientific Administrator to serve as the Director, Division of Extramural Activities (DEA). The Director, DEA, reports to the Director, NEI and serves as the principal advisor on research administration policies including peer review, grants management and administrative management of the Division. The incumbent oversees several distinct but related functions involving the extramural operations and has full managerial and executive responsibility for the following activities: Providing leadership and advice on extramural research grant, contract, and training program operations and policies within NEI; Providing oversight of grants management activities and implementation of grants policies; Providing guidance at the interface of grants management and the NEI Budget Office; Providing oversight and direction for the peer review of research applications, training applications and contract proposals. The incumbent represents NEI on extramural research administration and policy committees both within and external to NIH and HHS; Provides executive and managerial oversight of policy development for extramural research grant and contract review and management procedures; Provides overall management of the operations of the National Advisory Eye Council (NAEC) and serves as its executive secretariat and managing the resources for the DEA, including financial and personnel needs.

The Director, DEA will have responsibility for the development, implementation and dissemination of extramural review and grants management policies and procedures both internal and external to the NEI. The incumbent serves as an authoritative source on NEI extramural research peer review regulations, and grants management policies, and maintains awareness of new developments in research administration through interactions at professional conferences.

**QUALIFICATIONS REQUIRED:** Candidates must have an M.D., Ph.D., or equivalent degree in a field relevant to the position and substantial leadership experience in managing a federally-funded extramural science program. This position will be filled under a Title 42(f) excepted service appointment.

**SALARY/BENEFITS:** The salary for this position will be commensurate with qualifications and professional experience. A recruitment or relocation bonus may be available, and relocation expenses may be paid. A full package of federal Civil Service benefits is available, including: retirement, health and life insurance, long term care insurance, leave, and a Thrift Savings Plan (401K equivalent).

**HOW TO APPLY:** Submit a current curriculum vitae, bibliography, and full contact details for three references. In addition, applicants are asked to prepare two statements: a vision statement and a statement that addresses the specific qualification requirements (please limit both statements to two pages each). Send application package to Yireiza Williams at [ywilliams@nei.nih.gov](mailto:ywilliams@nei.nih.gov) by September 30.

NEI will begin accepting applications from August 25th through September 30th and plans to have the position open for at least 30 days, but will not close the applicant process until a candidate has been selected.

Information about NEI can be found at **[NEI.NIH.GOV](http://NEI.NIH.GOV)**

You may contact Yireiza Williams with questions and for more information about this vacancy at [ywilliams@nei.nih.gov](mailto:ywilliams@nei.nih.gov) or on (301) 451-1936.

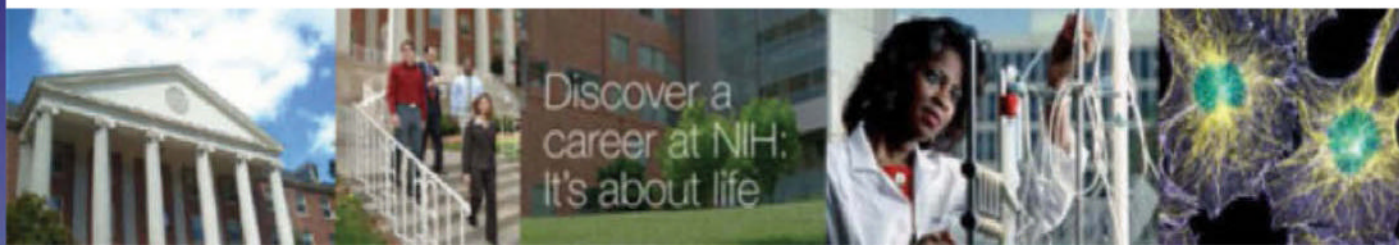
*HHS, NIH and NEI are Equal Opportunity Employers*



**National Eye Institute (NEI)**  
*Research Today...Vision Tomorrow*



# Director, Division of Extramural Science National Eye Institute



The National Eye Institute (NEI), a component of the National Institutes of Health (NIH) and the Department of Health and Human Services (DHHS), conducts and supports research, training, health information dissemination, and other programs with respect to blinding eye diseases, visual disorders, mechanisms of visual function, preservation of sight, and the special health problems and requirements of the blind.

Are you an experienced Scientific Researcher or Scientific Administrator in search of an exciting career opportunity? We may be the right place for you. The NEI at the NIH is seeking an exceptional Scientific Administrator to serve as the Director, Division of Extramural Science (DES). The incumbent plans and directs programs of research grants, cooperative agreements, individual and institutional research training awards, and research and development contract support for basic and applied clinical research and training as it relates to blinding eye diseases, visual disorders, mechanisms of visual function, preservation of sight, and the special health problems and needs of individuals who are partially-sighted or blind. The incumbent has responsibility for directing and managing multiple extramural scientific program initiatives and functions, managing the domestic and international extramural funding activities of NEI and providing policy direction. The incumbent advises the Director, NEI, regarding basic vision research activities, and coordinates with other NEI, NIH and DHHS organizations and the extramural community to accomplish Institute objectives. Additionally, the incumbent provides executive and managerial leadership in setting extramural scientific priorities of the Institute, making broad and significant decisions on scientific programs, developing Institute-wide policies and procedures, and determining resource allocation issues involving a major component of the Institute and a significant portion of NEI funding. Through his/her expertise and experience, the incumbent must be able to promote, manage, and oversee extramural research activities of national and international significance.

The incumbent serves as the principal advisor and liaison representing the DES and NEI on NIH work groups and committees pertaining to extramural science programs and activities and represents the Institute in interactions with the extramural community and at national and international conferences and seminars.

**QUALIFICATIONS REQUIRED:** Candidates must have an M.D., Ph.D., or equivalent degree in a field relevant to the position and substantial leadership experience in managing a federally-funded extramural science program. This position will be filled under a Title 42(f) excepted service appointment.

**SALARY/BENEFITS:** The salary for this position will be commensurate with qualifications and professional experience. A recruitment or relocation bonus may be available, and relocation expenses may be paid. A full package of federal Civil Service benefits is available, including: retirement, health and life insurance, long term care insurance, leave, and a Thrift Savings Plan (401K equivalent).

**HOW TO APPLY:** Submit a current curriculum vitae, bibliography, and full contact details for three references. In addition, applicants are asked to prepare a statement that addresses the specific qualification requirements (please limit the statement to no more than two pages). Send application package to **Yireiza Williams at [ywilliams@nei.nih.gov](mailto:ywilliams@nei.nih.gov)** by September 30.

Information about NEI can be found at **[NEI.NIH.GOV](http://NEI.NIH.GOV)**

You may contact Yireiza Williams with questions and for more information about this vacancy at **[ywilliams@nei.nih.gov](mailto:ywilliams@nei.nih.gov)** or on (301) 451-1936.

*HHS, NIH and NEI are Equal Opportunity Employers*



**National Eye Institute (NEI)**  
*Research Today... Vision Tomorrow*





The Broad Institute brings together a diverse group of individuals from across its partner institutions - undergraduate and graduate students, postdoctoral fellows, professional scientists, administrative professionals, and academic faculty. The culture and environment at the Broad is designed to encourage creativity and to engage all participants, regardless of role or seniority, in the mission of the Institute. Within this setting, researchers are empowered - both

intellectually and technically - to confront even the most difficult biomedical challenges. The Institute's organization is unique among biomedical research institutions. It encompasses three types of organizational units: core member laboratories, programs and platforms. Scientists within these units work closely together - and with other collaborators around the world - to tackle critical problems in human biology and disease.



**The Broad Institute is essentially an "experiment" in a new way of doing science, empowering this generation of researchers to:**

- Act nimbly. Encouraging creativity often means moving quickly, and taking risks on new approaches and structures that often defy conventional wisdom.
- Work boldly. Meeting the biomedical challenges of this generation requires the capacity to mount projects at any scale - from a single individual to teams of hundreds of scientists.
- Share openly. Seizing scientific opportunities requires creating methods, tools and massive data sets - and making them available to the entire scientific community to rapidly accelerate biomedical advancement.
- Reach globally. Biomedicine should address the medical challenges of the entire world, not just advanced economies, and include scientists in developing countries as equal partners whose knowledge and experience are critical to driving progress.

**Ryan W. Lavoie, JD** Associate Director: Talent Acquisition  
The Broad Institute of MIT and Harvard  
75 Ames Street, Cambridge, MA 02142  
E: [rlavoie@broadinstitute.org](mailto:rlavoie@broadinstitute.org)  
O: 617.714.8558 M: 603.583.1057



## Assistant Professor of Chemistry

The Department of Chemistry at The University of Chicago invites applications from outstanding individuals for the position of Assistant Professor of Chemistry. This search is in the areas broadly defined as inorganic, organic and physical chemistry. Applicants must apply online to the University of Chicago Academic Career website.

Inorganic chemists apply to <http://tinyurl.com/nq59kgr>, Organic <http://tinyurl.com/oxvy7n8>, and Physical <http://tinyurl.com/py98uyk>.

Please apply to one search only. Applicants must upload a cover letter, a curriculum vitae with a list of publications, a succinct outline of research plans and a one page teaching statement. In addition, three reference letters are required. At the time of hire the successful candidate must have a Ph.D. in Chemistry or a related field. Joint appointments with other departments are possible. Review of applications will continue until all positions are filled.

Referral letter submission information will be provided during the application process.

*All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, age, protected veteran status or status as an individual with disability.*

*The University of Chicago is an Affirmative Action / Equal Opportunity / Disabled / Veterans Employer.*

*Job seekers in need of a reasonable accommodation to complete the application process should call 773-702-5671 or email [ACOppAdministrator@uchicago.edu](mailto:ACOppAdministrator@uchicago.edu) with their request.*



## ASSISTANT PROFESSOR in Complex Systems

The Center for the Study of Complex Systems (CSCS) at the University of Michigan invites applications for a tenure-track position of Assistant Professor of Complex Systems. Candidates at a more senior-level will also be considered. The appointment will begin **September 1, 2016**. This is a University-year appointment. Information about the Center can be found here: <http://www.lsa.umich.edu/cscs>.

### Required Qualifications

Candidates must have a demonstrated research agenda focusing on complex systems. This may involve theoretical or applied research on complexity, including (but not limited to) mathematical and computational models in areas such as networks, computation, emergence, large events and robustness or applications where complexity lies at the core such as quantitative modeling of social systems, soft condensed matter physics, evolutionary or ecological dynamics, epidemiology and disease transmission, artificial life, neuroscience, and cognition. Preference will be given to candidates with a track record of working across disciplines.

### How to Apply

All application materials must be uploaded onto this website:

<https://complexsystems-lsa.applicantstack.com/x/apply/a2guio5y9cxr>

The position is based in CSCS but will be a joint appointment with another department. In the cover letter, candidates should identify one or more partner departments at the University of Michigan suitable for such a joint appointment. Applicants must submit: a current CV, statement of current and future research plans, a statement of teaching philosophy and experience, evidence of teaching excellence (if any) and one writing sample. At least three letters of recommendation are required and must be uploaded onto the same website. Applications will be reviewed starting **October 1, 2015**. Applications will be accepted until the position is filled.

*Women and minority candidates are encouraged to apply. The University of Michigan is an equal opportunity/affirmative action employer and is supportive of the needs of dual career couples.*





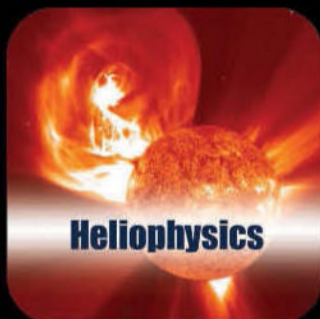
**NASA**

**Postdoctoral Program**

administered by Oak Ridge Associated Universities



**Earth Science**



**Heliophysics**



**Astrophysics**



**Planetary Science**



**Astrobiology**



**Space Bioscience**



**Aeronautics &  
Engineering**



**Human Exploration  
& Operations**



**Space Technology**

**The NASA Postdoctoral Program (NPP) supports NASA's goal to expand scientific understanding of Earth and the universe in which we live.**



The NASA Postdoctoral Program offers U.S. and international scientists the opportunity to advance their research while contributing to NASA's scientific goals. The NPP supports fundamental science; explores the undiscovered; promotes intellectual growth; and encourages scientific connections.

### **Details**

- Annual stipends start at \$53,500, with supplements for high cost-of-living areas and certain degree fields
- Annual travel budget of \$8,000
- Relocation allowance
- Financial supplement for health insurance purchased through the program
- Appointments renewable for up to three years
- Approximately 90 Fellowships awarded annually

### **Application Deadlines**

Three each year - March 1, July 1, and November 1

**Apply at <http://nasa.orau.org/postdoc>**



# The Association for Women in Science

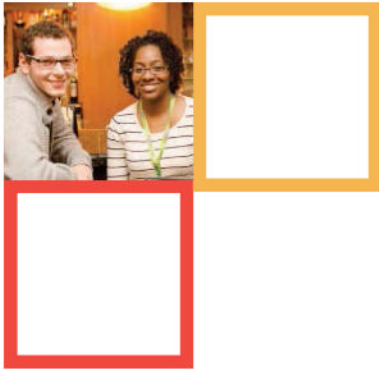
## Smart Women Doing Cool Stuff

Join our community of over 20,000 women and men working in STEM fields.



Visit [www.awis.org](http://www.awis.org) and join today.

**AWIS**



OUT IN SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS, INCORPORATED

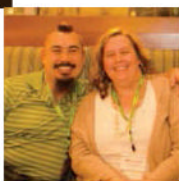
DIVERSITY IN PASSION, UNITY IN PRIDE

# 2015 NATIONAL CONFERENCE

NOVEMBER 13-15, 2015 | PITTSBURGH, PA

A decorative arrangement of three empty colored squares: a green one at the top, a yellow one to the left, and a pink one to the right.

**Carnegie  
Mellon  
University**



**WWW.OSTEM.ORG FOR MORE INFO.  
AND TO GET REGISTERED!**



## EDITOR'S PICK



## Flagging our motion in time

From Adrian Ellis

You ask why we move forward in time and make it clear that physics has no clear answer as to why time passes (5 September, p 34). The article reminded me of an ancient Zen koan.

Two monks were watching a flag flapping in the wind. One said to the other, "The flag is moving." The other replied, "The wind is moving." A Zen master, walking nearby, overheard them. He said, "It is not the flag nor the wind that is moving but your minds."

The idea that our minds experience the four-dimensional "landscape" of physical reality in a chosen time direction would explain the phenomenon of time passing without violating any physics. Perhaps the Zen master was right philosophically and scientifically? *London, UK*

Letters should be sent to:  
Letters to the Editor, New Scientist,  
110 High Holborn, London WC1V 6EU  
Email: letters@newscientist.com

Include your full postal address and telephone number, and a reference (issue, page number, title) to articles. We reserve the right to edit letters. Reed Business Information reserves the right to use any submissions sent to the letters column of *New Scientist* magazine, in any other format.

## Beyond cracking down on antibiotics

From James Barrow,  
Cystic Fibrosis Trust

You report moves in the UK to prevent oversubscribing of antibiotics to curb resistant infections (22 August, p 6). People with cystic fibrosis spend their entire lives fighting off infection to slow the progression of lung disease. Nine out of ten people with the condition eventually die from respiratory failure.

Antimicrobial resistance poses a particularly significant threat, which is why the Cystic Fibrosis Trust is working with scientists and the pharmaceutical industry to bring new treatments to market. While control measures are welcome, this is a global problem requiring coordinated action across all governments and societies.

I recently visited a pharmacy in Spain for antiseptic cream to treat a minor ailment. I was rather alarmed to be offered an array of products including an antibiotic. *London, UK*

## Let us consider the arrows of times

From Philip Abbott

*New Scientist* recently considered conundrums such as the imbalance between matter and antimatter, the "arrow of time", and the concept of "before the big bang" (5 September, p 30). Might some of these be resolved, or at least recast, if the big bang created two universes simultaneously: one of matter progressing in a positive direction on the time axis, and another, otherwise identical, of antimatter occupying the same space but progressing in a negative direction on the time axis?

Or why restrict it to one time axis? Why not multiple matter/antimatter universes occupying the same space but

progressing in opposite directions along time axes that are at "right angles" to each other – that is, mutually orthogonal?

This would at least have the virtue of removing the matter/antimatter imbalance as well as introducing a pleasing symmetry to the event. It may even impinge on dark matter and dark energy, as, presumably, gravitation would be universal and there would be twice as much matter (as we can currently see) in existence for each time axis.

*London, UK*

## The roots of consciousness

From Paul Mealing

I agree with Peter Halligan and David Oakley that consciousness plays a key role when it comes to communicating with others in a creature's social milieu (15 August, p 26). I suspect, however, that this is a secondary benefit rather than the primary evolutionary driver.

In virtually all discussions on consciousness the emphasis is on cognitive abilities and benefits. It is more likely that feelings and emotions were the main drivers, especially fear and pain, pleasure and desire. For plants, conscious feelings would have no benefit whatsoever. What's the point of experiencing fear or pain if one can't avoid its source?

It is ironic that science does its best to downplay consciousness, especially its role in providing a sense of individual agency, when there would be no science at all without it. In answer to the oft-asked question: why is there something rather than nothing? – there is nothing when you're unconscious, and without consciousness the universe might as well not exist. It's only because of consciousness that the universe has meaning, and meaning has been most manifestly realised through science.

*Melbourne, Australia.*

From Steve Brewer

When you truly accept that minds are embodied then there are no unconscious processes. Instead, my conscious states are how my body feels as it encounters the world and acts on it. We can now see how the counter-intuitive argument that consciousness is disconnected from our actions is an artefact caused by the dissection of mind from body. *St. Ives, Cornwall, UK*

From Ryan Shirlow

An internal narrative for social benefit doesn't actually require consciousness: it could simply be facilitated by a collaboration between unconscious processes. In that case we would be a species of zombie (in the philosophical not the filmic sense).

We are still left wondering why we have a sense of self that is exquisitely and individually felt. I am more attracted to the suggestion that consciousness is some kind of innate potential of very complex material systems, processing information in a recursive fashion.

*Leeds, UK*

## Reason and taking responsibility

From Iain Hogg and Barry Korklin

Adrian Bowyer makes an interesting point that either individuals and the people who police them are responsible for what they do, or nobody is (Letters, 8 August). I think, though, that this reasoning can be taken further.

Surely, if we all have no control over our actions, then we also have no control over seeing that we have no control. We would also have no control over (apparently) deciding to be more lenient towards criminals – if this is what we do – as a result of realising that they have no control over their actions. Equally, we would have no control over not doing so. The

**f “If I saw my own genome,  
I couldn’t read it”**

Russell Bushby is sceptical of a “right to see our dead relatives’ genomes” (5 September, p 26)

“end result” is not necessarily the same either way, as Bowyer claims, if by this he implies that the research quoted will not alter our attitude towards, and the sentencing of, criminals.  
*Hull, East Yorkshire, UK*

## What we really fear from nuclear power

*From Sam Edge*

Geraldine Thomas may have misunderstood “public anxiety over nuclear power” (22 August, p 26). I suspect that the problem is simply that from long experience people just do not believe the industry’s repeated attempts at public relations. The endemic culture of secrecy, obfuscation and plain lying about safety incidents doesn’t inspire confidence. Fatuous attempts to rebrand, such as renaming the Windscale reprocessing plant in the UK as Sellafield, haven’t helped either.

From a technical standpoint, the continuing reluctance to fund development of thorium reactors

rather than the uranium favoured by the original considerations of generating plutonium for military use is troubling. I don’t believe nuclear power is the bogey that some environmentalists claim. But in its current form neither is it the panacea claimed by those with a vested interest.  
*Ringwood, Hampshire, UK*

*From Perry Bebbington*

Thomas makes a good case for the safety of nuclear power but misses one reason for public mistrust of the nuclear industry. Its representatives on TV in the 1960s told us how completely safe nuclear power was, and that there could not possibly be any kind of serious accident. This was despite the fact that grave dangers had already been demonstrated by the accident at Windscale on 10 October 1957.

Even at a young age something told me not to believe them: if the public is to ever trust the nuclear power industry then it needs to come clean not only about the risks but also about the lies it told in the past.

*Kimberley, Nottinghamshire, UK*

*From Roy Harrison*

Regardless of whether people make unreasonable associations between nuclear power and nuclear war, or harbour unreasonable fears of small doses of radiation, it is entirely reasonable for them to fear being made homeless.

Compare the area of the exclusion zone around the site of the Chernobyl reactors in Ukraine with southern England. The risk of a disaster happening is, I hope, very, very small: but, when it happens, the consequences can be very, very severe.

*East Wellow, Hampshire, UK*

## Panspermia coming in and going out

*From Richard Price*

You report astrobiologist Chandra Wickramasinghe saying that genetic material and living organisms are continually exchanged between Earth and neighbouring star systems (8 August, p 28). Is this a two-way exchange? If so, it’s hard to

reconcile with the report on the same page of a balloon that, following a meteor shower “returned with samples of microorganisms found 27 kilometres up, too high to have been lofted from Earth’s surface”. Surely to get to a neighbouring star system bugs would have to ascend further?

*Chipping Sodbury, Gloucestershire, UK*

## The theatricality of life and death

*From Brett Porter*

I may be able to help explain Bob Trenkamp’s observation that a standing position using leg muscles for cardiopulmonary resuscitation (CPR) seemed to be lost for decades after failing to catch on (8 August, p 23).

As a 14-year-old in 1973 I realised that young people, as well as older people, may not be able to perform kneeling CPR. I asked my science teacher whether using feet and legs would be better. In 1976, when I started ambulance officer training, while still at school, I got to experiment on our Resusci Anne mannequin. My demonstrations to trainers were ridiculed.

Allowing for discrimination by age and pecking order, I think the main problem may lie with how it looks to stand over, and then stand on, a recumbent casualty. Hollywood prefers the dramatic “down there with ‘em” effect.  
*Burleigh Heads, Queensland, Australia*

## For the record

■ We meant to say that Ebola threatens western lowland gorillas (5 September, p 12).

■ Some adjustment needed: at the size we printed the stereoscopic images of gibbon skeletons, you need to unfocus your eyes, not cross them, to try to see the 3D effect (5 September, p 24).

TOM GAULD







THE new president of the British Science Association, Athene Donald, has spoken out ahead of her inauguration to condemn early influences that drive women away from careers in science, technology, engineering and maths (STEM). In particular she highlighted girls' toys that foster passive play, "combing the hair of Barbie, for instance".

Gallantly riding to the rescue is the California-based MGA Entertainment, clutching the reels of their new TV series *Project Mc²*, which features a gang of scientifically adept girl sleuths. In an excruciating buzzword pile-up, the press release trumpets: "Girl Power for the YouTube Generation: *Project Mc²* Brings STEM to Life For Tweeners".

Headless of our agony, it gallops on: "Featuring the tagline 'Smart is the New Cool', *Project Mc²* focuses on four young girls who are all smart, sassy and very stylish - a far cry from the traditional 'geek' image associated with STEM subjects."

At this point the ghost of the European Commission's spectacularly awful *Science: It's a Girl Thing!* video looms large ([bit.ly/NS\\_girlthing](http://bit.ly/NS_girlthing)).

But are dolls really to blame for driving girls away from STEM careers? If anyone knows, it's MGA Entertainment, as the firm happens to own the phenomenally successful Bratz brand, a collection of sassy, stylish dolls described by a company spokesperson as having core values of "friendship, hair play and a 'passion for fashion'." Naturally, *Project Mc²* comes with its own range of dolls with flowing tresses. Fancy that.

IF TOO much hair play is bad, airplay may be even worse - at least, if you're a Canadian government scientist. Tony Turner at Environment Canada was given compulsory leave after taking aim at Prime Minister Stephen Harper in a protest song.

A long-time folk singer, Turner's catchy ditty *Harperman*

went viral after a performance of the song was uploaded to YouTube. The video contains lines such as "Who won't buy into climate change until it's sold on the stock exchange? Harperman!", and the chorus "Harperman, it's time for you to go".

In response to the lab-coated Woody Guthrie's question "Who stifles all dissent... Who muzzles the scientist?", the authorities have sent Turner home pending an investigation into his conduct, during which he is not answering any media requests.

CANADIAN authorities have prior form for overzealously policing researchers (12 April 2014, p 26). A colleague reports that picking the brains of a geologist there required submitting his questions in advance to a press officer, then waiting several days for permission to conduct the interview.

"I suppose if you're going to delve into politically charged topics such as river systems that existed around a billion years ago, you've got to expect the authorities on your back," he sighs.

RESPONDING to our search for a retort to unimaginably stupid statements (8 August), Andy Johnson-Laird writes: "For many years the military acronym fubar has served this purpose".

Feedback thinks that this term more adequately describes things that have gone very wrong, rather than things that simply are very wrong. But Andy helpfully continues: "Around our office we use PFS [plain flipping stupid?] to describe logic that is beyond redemption and unworthy of a response."

ECONOMICS is often lambasted as the dismal science, so it shouldn't surprise us that one of its practitioners has come up with a retort that fits our requirements. Gavin Maclean informs us of economist Robert Wade's response to the premise that markets are imperfect, but governments are even more imperfect: "This argument has some way to go before it can even be called simplistic."

AS WE explore the depths of wrongness, Murphy's Law gives hot pursuit. "You attribute the expression 'beyond wrong' to Michael Shermer", writes John, who thinks Shermer was merely echoing the Swiss theoretical physicist Wolfgang Pauli.

Pauli did not suffer fools gladly, John informs us, "and is famously reported to have said: 'This isn't right. This isn't even wrong.'"

FINALLY, Phillip Sheeran-Purcell sends evidence of what he calls "a new class of object" - a spoon from his trendy local coffee shop, pressed from a thin wood veneer. "As soon as it comes in contact with soup, it loses its shape and becomes a stick, and the soup falls off," laments a hungry Phillip.

He suggests this may be a mysteriously forgotten Heisenberg



idea, namely "the unfunctionality principle", whereby a functional item loses that function the instant you try to employ it.

How to describe such items? "As to be defunct implies having been useful at some stage, I suggest 'afunct'," writes Phillip, "and I welcome news of other discoveries of things that are afuncts." Feedback does too, and is certain readers will be stirred into action.

You can send stories to Feedback by email at [feedback@newscientist.com](mailto:feedback@newscientist.com). Please include your home address. This week's and past Feedbacks can be seen on our website.

A low bar is set for Tesco's premium range tomatoes, which Christian Smith is told are: "Intensely sweet and juicy, with a beautiful old-fashioned tomato aroma".

## Railing against it

Edinburgh finally got its tram system last year, which was over-budget and behind schedule. Most of the problems were due to having to lay the rails in the road. Why didn't Edinburgh and other UK cities go for trolley buses – electric buses powered from overhead wires – instead of trams?

■ From my experience in having delivered a rail-based, road-running urban tramway within budget, I can think of several reasons why trolley buses were not preferred.

Unguided trolley busways with the same passenger capacity as tramways require far more space. Drivers of trolley buses cannot match the precision of a vehicle guided by rails, so they need more space as a safety buffer.

Guidance systems for buses that don't run on rails do exist, but their use of space is not as efficient as that of a tram. Such guidance systems may also prevent other traffic from using the busway and so cause congestion.

The guided busway has not proved to be an alternative to the tramway; the two systems are each suitable for different circumstances. For example, a tramway might be the right solution for transporting extremely high numbers of passengers through very limited volumes of space.

As far as budgeting goes, few tramways or guided trolley busways are built each year, so

there is little experience to draw on when it comes to identifying key cost issues.

The detailed investigation needed to establish the cost of a system is in itself very expensive and potentially disruptive. Sometimes, it might be practical to carry out the exploration and construction at the same time, and to accept the resultant massive uncertainties in cost.

But, obviously, that decision is a political issue rather than an engineering one.

*J. H. M. Russell  
Golant, Cornwall, UK*

## Selected selections

The only genetic changes in humans we ever hear about are those producing diseases such as cystic fibrosis. Has anyone identified any genetic changes within recent generations that make individuals possessing them “more fit” to thrive in today's environment? Would we even know these changes if we saw them? And would we consider them normal for healthy humans?

### “Some indigenous Amazonians lose less sodium in their sweat than average citizens of the US”

■ The example that is most often cited of a positive genetic change within a recent generation is that of sickle-cell anaemia, which appears to confer an advantage to people who have it in places

where malaria is endemic. While we wouldn't necessarily consider having sickle-cell anaemia as a healthy trait, carrying a copy of the “faulty” gene confers a level of resistance to malaria, and is therefore

### “Sickle-cell anaemia appears to confer an advantage in places where malaria is endemic”

selected for in populations exposed to malaria parasites.

This is generally taught in most high-school biology courses as an example of human natural selection, as well as the idea that a trait is neither positive nor negative intrinsically: rather, its value is dependent on the environment.

However, another example of a positive trait that is necessary for survival in today's environment is our adjustment to being able to cope with the high level of sodium in our diet.

In populations that have a low daily salt intake, such as some indigenous Amazonians, people can retain salt effectively; they lose less sodium in their sweat and urine compared with average citizens of the US. If they are subsequently exposed to a high-sodium diet, however, this ability to retain salt works against them, and many may suffer from hypertensive disorders and die at a very young age from heart disease.

*Mark Bilger  
Livonia, Michigan, US*

## This week's questions

### MAGNETIC REPULSION

Would there be any serious consequences if the human body were subjected to a very strong magnetic field, for example, the magnetic field generated by the Large Hadron Collider?

*Katie Morris  
Selby, North Yorkshire, UK*

### GROW YOUR OWN

If we did not import any food into the UK, how large a population could we sustainably support by producing our own? Fresh water is obviously an important consideration too.

*Jim Watts  
Aberdeen, UK*

### AGGRESSIVE PITCH

Why does feedback between a microphone and speaker generate a high-pitched noise, and not a low one?

*Tony Sharpe  
Almonte, Ontario, Canada*

### SUNSHINE DOWN UNDER

I read in *New Scientist* that exposure to the sun in winter at latitudes higher than about 35° results in negligible vitamin D production (9 August 2014, p 34). For many years here in Tasmania (40° south) I have been exercising naked in the sun just after midday to dose up on vitamin D. But have I been wasting my time in winter?

*Guy Burns  
Devonport, Tasmania, Australia*

The writers of answers that are published in the magazine will receive a cheque for £25 (or US\$ equivalent). Answers should be concise. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and an email address if you have one. *New Scientist* retains total editorial control over the published content.

Reed Business Information Ltd reserves all rights to reuse all question and answer material that has been

submitted by readers in any medium or in any format and at any time in the future.

Send questions and answers to The Last Word, *New Scientist*, 110 High Holborn, London WC1V 6EU, UK, by email to [lastword@newsscientist.com](mailto:lastword@newsscientist.com) or visit [www.newsscientist.com/topic/lastword](http://www.newsscientist.com/topic/lastword) (please include a postal address in order to receive payment for answers).

Unanswered questions can also be found at this URL.

## Question Everything

The latest book of science questions: unpredictable and entertaining. Expect the unexpected

Available from booksellers and at [newsscientist.com/questioneverything](http://newsscientist.com/questioneverything)







NOBCChE

## Bridging Generations Through STEM

Inspire • Connect • Create

September 21 • 26

## Renaissance

Sea World Orlando, Florida.

**Join or Rejoin as a Member of NOBCChE**

[www.nobcche.org](http://www.nobcche.org)